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Laser Geodynamic Satellite Thermal/Optical/Vibrational Analyses and Testing

Final Report Addendum

Volume II
Technical Report

Book 2

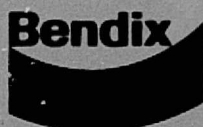
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DR No. MA-04
DPD No. 296
Contract NAS 8-30652

January 1975

Prepared for:

George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama 35812



**Aerospace
Systems Division**

Ann Arbor, Michigan

Laser Geodynamic Satellite Thermal/Optical/Vibrational Analyses and Testing

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VOLUME II

Book 2

This Book 2 of Volume II contains only Appendix E.

APPENDIX E

31 JANUARY 1975

LASER GEODYNAMIC SATELLITE (LAGEOS)

DIHEDRAL ANGLE IMPROVEMENT PROGRAM

Prepared for

Bendix Aerospace Division

3300 Plymouth Road

Ann Arbor, Michigan 48107

In response to Contract No. T2997

Amendment No. 4



Optical Systems Division

ITEK CORPORATION • 10 MAGUIRE ROAD • LEXINGTON, MASSACHUSETTS 02173

FOREWARD

This final report, prepared by Itek Corporation, Lexington, Massachusetts under Purchase Order No. T-2997, amendment No. 4 to Bendix Aerospace Systems Division, Ann Arbor, Michigan covers work performed from 27 September 1974 to 31 January 1975 under the direction of Bendix Aerospace. The Bendix project manager was Mr. John M. Brueger.

The following Itek personnel were the primary contributors to the work summarized in the report:

Project Manager	M. Kahan
Chief Engineer	M. Rimmer
Lead Optical Engineer	R. Byrd
Optical Analysis	C. King

The report documents the evaluations performed to recommend the specific LAGEOS cube-corner dihedral angle which might further optimize the far field pattern on the earth which results from satellite laser ranging. This study should be taken together with Book 2 of Volume II of DR No. MA-04 (DPD No. 296, Contract NAS-8-30658, October 1974) which showed that the planned hardware may have been configured with too large a dihedral angle and which also noted an apparent paradox between measured and predicted far field characteristics (differences are shown in this report to be due to polarization and diffraction effects).

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ABSTRACT/SUMMARY

The purpose of this Itek Corporation LAGEOS effort was to provide a more detailed comparison of the differences between various theoretical and experimental results relative to the quality of a retro-reflected laser signal's far field diffraction pattern. The resultant recommendations helped to further optimize the cubes relative to the specific cube geometries and configurations of interest. They were one of several inputs used by Bendix Aerospace, NASA and SAO in configuring a Laser Geodynamic Satellite to accurately establish the physical motions and distortions of the solid earth. The overall effort was conducted as a part of the Earth and Ocean Physics Application Program (EOPAP). Interested readers are referred to Book 2 Volume II of DR No. MA-04 (DPD No. 296, Contract NAS 8-30658, October 1974) for additional background material relative to this study.

The main tasks performed by Itek involved an interferometric evaluation of several cubes, a prediction of their dihedral angles, a comparison of these predictions with independent measurements, a prediction and comparison of far field performance, recommendations as to revised dihedral angles and a subsequent analysis of cubes which were reworked to confirm the recommendations. A tolerance study and theoretical evaluation of several cubes was also performed to aid in understanding the results. The far field characteristics evaluated included polarization effects and treated both intensity distribution and encircled energy data. The energy in the 13.2 - 16.9 arc-sec annular region was tabulated as an indicator of performance sensitivity as this was roughly the region where comparable Bendix Aerospace test data was taken.

The results are provided rather succinctly in Appendix D in viewgraph form. They show the average dihedral angle of an original set of test cubes to have been 1.8 arc-sec with an average far field annulus diameter of 18 arc-sec. Since the peak energy in the 13.2 - 16.9 arc-sec annulus was found to occur for a 1.35 arc-sec cube, and since cube tolerances were shown to increase the annulus diameter slightly, a nominal dihedral angle of 1.25 arc-sec was recommended (measured data also showed a tendency to a high annulus diameter and a low percent of the incident energy in the 13.2 - 16.9 arc-sec region). Tests and evaluations were subsequently performed on a set of reworked cubes of smaller dihedral angle to confirm these recommendations. Although the interferometrically predicted dihedral angles on the reworked cubes were about 0.5 arc-sec smaller than desired/mechanically measured, and the far field measurements had a higher percent of the

incident energy in the annulus than predicted (and a larger centroid diameter), the results tended to confirm the 1.25 ± 0.5 arc-sec dihedral angle recommendation.

It was noted that differences between measured and predicted far field results could have been caused by a reduced annulus diameter. Also, the far field annulus was shown to be larger than geometrical predictions due to diffraction/polarization effects. The mechanically measured angles for the reworked cubes had a constant offset from the interferometrically predicted dihedral angles. For this reason it was suggested that production cubes be checked interferometrically to verify their dihedral angles.

Agreement between the Itek and SAO models for the far field intensity distribution was obtained during the course of the study which lends added confidence to the conclusions reached, although the practical results of the changes were quite small (e.g. a revision of the Itek model changed the total energy in the 13.2 - 16.9 arc-sec annulus by less than 0.1% of the total energy).

Future work suggested includes a cross-check by Itek of the production cubes. Also, an additional treatment of field angle/polarization inputs may be desirable. Eventually, an evaluation of performance at shorter wavelengths and of different cube types/cube corner arrays might be of interest, as might a further comparison of predicted vs. measured far field characteristics where some differences still exist.

Background

This report is submitted by Itek Corporation's Optical System Division in accordance with the requirement of contract T2997 ammendment No. 4, to furnish a detailed evaluation of potential LAGEOS solid fused silica cube-corner retro-reflectors. Readers interested in supplemental detail should refer to Book 2 of Volume II of DR No. MA-04, previously referenced for added background material. This earlier document provides information on the procedures, polarization effects, the computer output formats' meanings and the detailed modelling assumptions which have been used during the study.

The main tasks reported on by Itek in the earlier report were the modelling, over field angle, of an individual suprasil cube-corner having potential manufacturing variations (e.g. surface quality and angular anomalies) and environmental loadings. The far field characteristics treated included both intensity patterns and encircled energy data. Thus, the energy in the $32 - 42 \mu$ radian annular region was tabulated as an indicator of performance sensitivity as this was roughly the region where comparable Bendix Aerospace test data was taken.

The results of this earlier study showed that given no reflection or absorption losses, a 1.5 arc-sec cube returned 21.6% of the incident energy on-axis and 10.8% at -15° off-axis in the annulus of interest. The retroreflector's encircled energy data was relatively insensitive to irregular dihedral angle errors and surface quality effects. However, up to 6.8% changes in annular energy (e.g. 22% to 14%) were noted when all dihedral angles were simultaneously offset in the same direction by 0.5 arc-sec. The 3-D temperature profiles analyzed changed the annular return only about 1%. Finally, the axial thermal gradients were found to compensate the radial gradients - the individual gradient types having fairly high sensitivity. In no case which was analyzed to simulate actual cube performance (as opposed to pure sensitivity determinations) did the annular return drop to 50% of that of the nominal cube - the criterion supplied us to assess degradation severity.

Future work suggested included a more detailed comparison of the differences between various theoretical and experimental results for the specific cube geometries and test configurations of interest. It was thought that this might help to further optimize the cubes. The current report is a result, in part, of this earlier (Phase I) recommendation.

Introduction

The purpose of this Itek Corporation Contract was to resolve contradictions between experimental test results and analytical predictions and to recommend an optimum cube dihedral angle for manufacturing. The work performed at Itek consisted of three main tasks.

1. A tolerance analysis of perfect cubes with different dihedral angles, and of cubes with dihedral angle errors.
2. Analysis of six existing cube corners to predict cube dihedral angles and resultant far field patterns.
3. Analysis of three reworked cubes to predict cube dihedral angles and far field patterns.

Each portion of this study is presented in the body of this report and a recommendation of a dihedral angle is made so as to optimize performance.

Tolerance Study

The customer requirements dictate that the maximum energy be located in a 13.2 - 16.9 arc-seconds annulus diameter. According to geometrical optics a perfect cube with equal dihedral angles of 1.5 arc-seconds* will produce the maximum energy in this annulus. This tolerance study includes the effects of diffraction and polarization in computing the energy in the 13.2 - 16.9 arc seconds annulus.

Under Phase I of the contract perfect cubes with dihedral angles of 1.5 and 2.1 arc-seconds were analyzed. In order to find the dihedral angle that will produce the maximum percent energy in the 13.2 - 16.9 arc-second annulus additional perfect cubes with dihedral angles of 0.9, 1.25, and 1.75 arc-seconds were analyzed to provide a range. In all cases the wavelength was assumed to be 6328A and the input light was linearly polarized along a real edge. The computer output that resulted from the tolerance study is given in Appendix A.

Since the energy is to be maximized in the 13.2 - 16.9 arc-second annulus the encircled energies in this annulus were extracted from Appendix A and are given in tabular form in Table 1 and plotted versus dihedral angle in Figure 1. As may be seen from Figure 1 the peak encircled energy for a perfect cube occurs with a dihedral angle approximately 1.25 arc-seconds. In order to approximate the encircled energy over a wide range of dihedral angles, additional encircled energy tables were obtained for 0.0, 0.25, 0.5 and 0.75 arc-second dihedral angles. The encircled energy tables for these dihedral angles are also given in Appendix A.

* Dihedral angle as used in this report is the deviation from 90°

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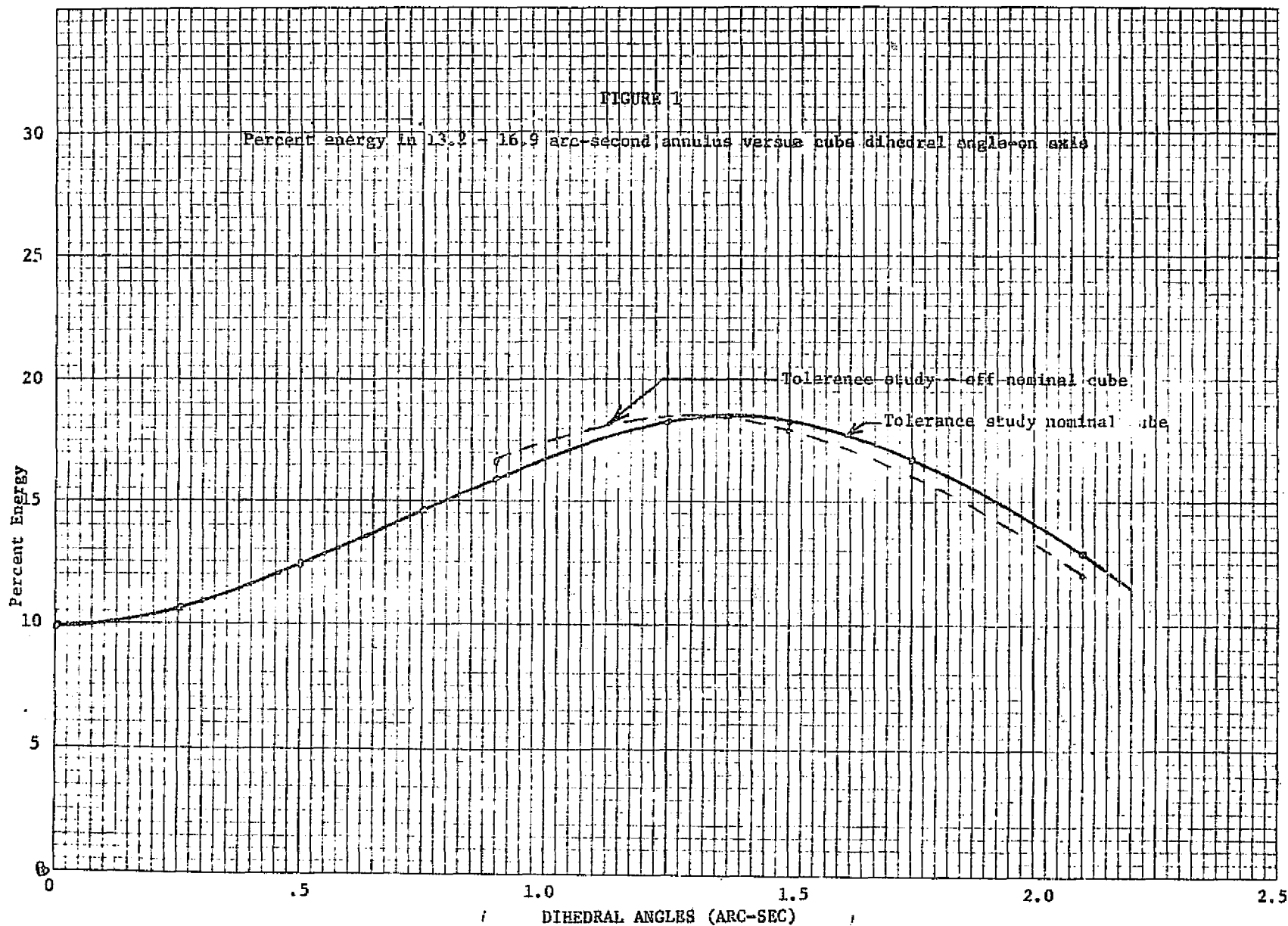
TABLE 1
TOLERANCE STUDY
ENCIRCLED ENERGY & APPARENT
CENTROID DIAMETER
ON-AXIS

CASE	PERCENT ENERGY	APPARENT
	<u>13.2 - 16.8 ARC-SEC</u>	<u>CENTROID DIAMETER</u> <u>(ARC-SEC)</u>
0.9 Arc-Sec Nominal Cube	16.0	12.4
0.9 Arc-Sec Off Nominal Cube*	16.7	13.4
1.25 Arc-Sec Nominal Cube	18.3	14.4
1.5 Arc-Sec Nominal Cube	18.5	16.5
1.5 Arc-Sec Off Nominal Cube *	18.2	17.3
1.75 Arc-Sec Nominal Cube	16.8	18.6
2.1 Arc-Sec Nominal Cube	13.0	22.0
2.1 Arc-Sec Off Nominal Cube *	12.3	22.4

* .0, + .5, -.5, ARC-SEC ERRORS

FIGURE 1

Percent energy in 13.2 - 16.9 arc-second annulus versus cube dihedral angle on axis



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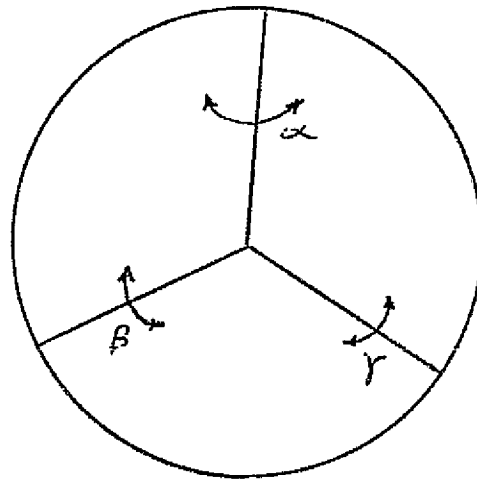
The cube was also analyzed with the three dihedral angles of the cube having different values as shown in Figure 2. The 1.5 arc second off nominal cube and the 2.1 arc-second off nominal cube were analyzed under the first phase of the contract. The results for a 0.9 arc-second off nominal cube are given in Appendix A. A plot of the encircled energy in the 13.2 - 16.9 arc-second annulus is denoted in figure 1 by the dashed line (---). Since the energy increases at an average dihedral angle value of 0.9 arc second and decreases at an average dihedral angle values of 1.5 and 2.1 arc seconds it is assumed that this variation in dihedral angles spreads the energy.

In order to verify the effect of variations in the dihedral angles on the energy distribution, the centroid of the annulus of energy was also obtained from the encircled energy curves. Here the annulus centroid is assumed to be the position of the maximum slope of the encircled energy curves. These values are also given in Table 1. The variation of annulus centroid diameter with cube dihedral angle is denoted by a solid line in Figure 3.

The diameter of the annulus centroid based upon a purely geometrical spread is also plotted in Figure 3 as a dashed line (---). It was proposed that the differences between the geometrical predictions and the analyses was caused by the combination of polarization and diffraction. If this were the case large dihedral angles on a retroreflector should produce the same annulus centroid diameter as the geometrical and polarization/diffraction based analyses. A cube with a dihedral angle of 5.0 arc-seconds produced matching annulus diameters (not shown on the graph) for both geometrical and analytical predictions (47.5 sec). In addition three cases were analyzed with no phase differences between the sectors due to polarization. The results of these analyses are noted in Figure 3 by the dotted squares (\square). Since these values closely approximate the geometrical predictions, the conclusion is that deviations from the geometrical prediction are caused mainly by polarization and only slightly by diffraction in the dihedral angle range of interest.

FIGURE 2

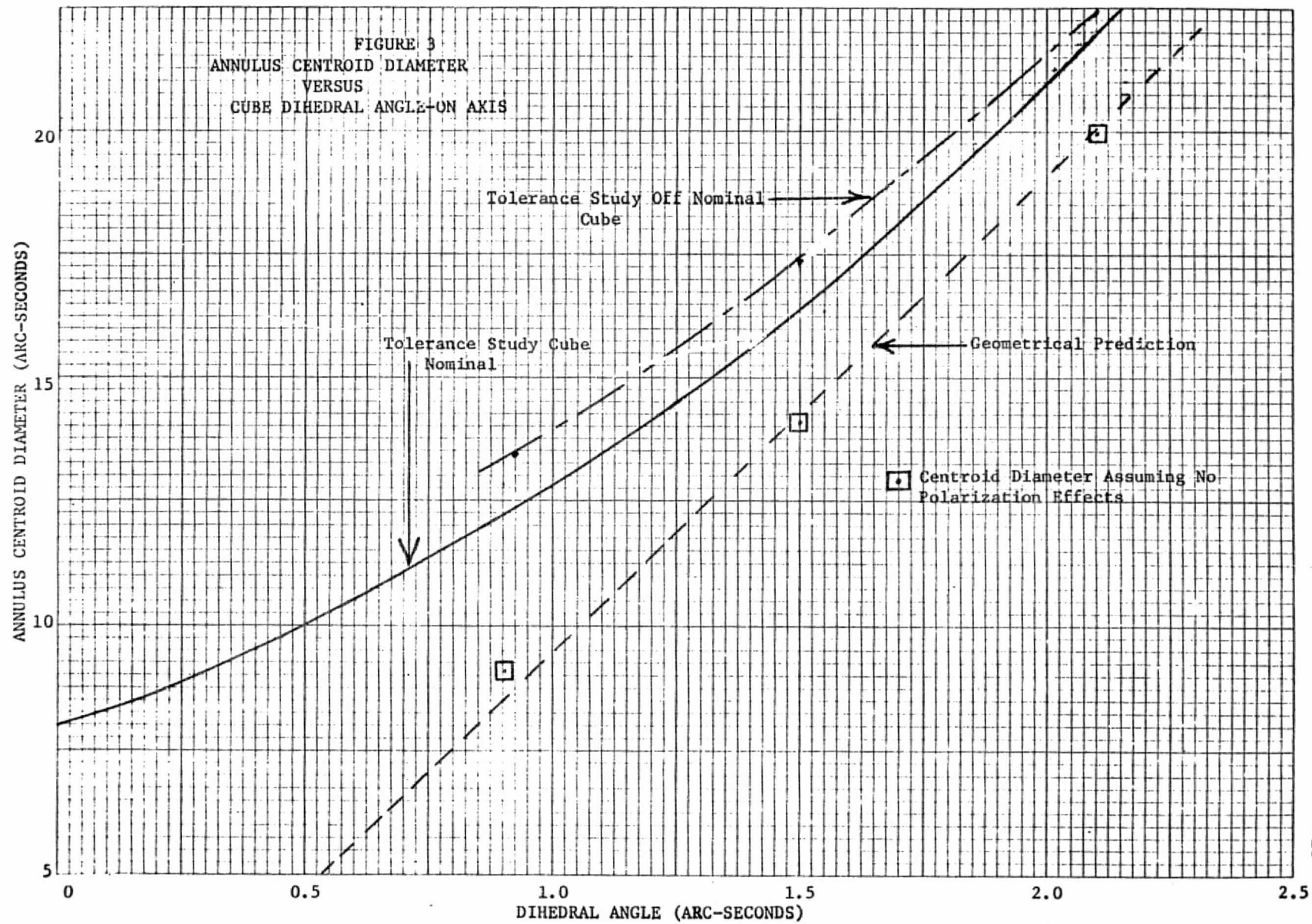
Dihedral angles used in the tolerance study of the off nominal
cube corner retroreflector



	<u>0.9 sec cube</u>	<u>1.5 sec cube</u>	<u>2.1 sec cube</u>
α	0.9	1.5	~2.1
β	0.4	1.0	~1.6
δ	1.4	2.0	~ 2.6

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Cube Analysis

In addition to the tolerance study, analyses were made by Itek on six existing cubes for comparison with the tolerance study and previous measurements made by Bendix. The handling/cleaning procedure used involved the careful inspection and subsequent testing of the retroreflectors in a Twyman-Green Interferometer and the use of the resultant interferograms to predict the dihedral angles and the far field patterns of the cubes.

Test Procedure

The schematic of the test setup of the Twyman Green Interferometer used in obtaining the interferograms is shown in Figure 4. The cube corner was carefully tilted approximately 1° to avoid reflection off the front surface. The input beam to the cube was linearly polarized with the direction of polarization parallel to a real edge. The beam exiting the cube consisted of two orthogonal polarizations, one parallel to the input beam. The output beam was then linearly polarized in the same direction as the input beam in order to eliminate D.C. background from the other polarization. An air wedge was then obtained by tilting the reference mirror of figure 4 such that 4 - 5 fringes were obtained on the closed side of the air wedge. The interferometer was automatically calibrated prior to use due to the unique properties of the cube corner. This is discussed in more detail in appendix D.

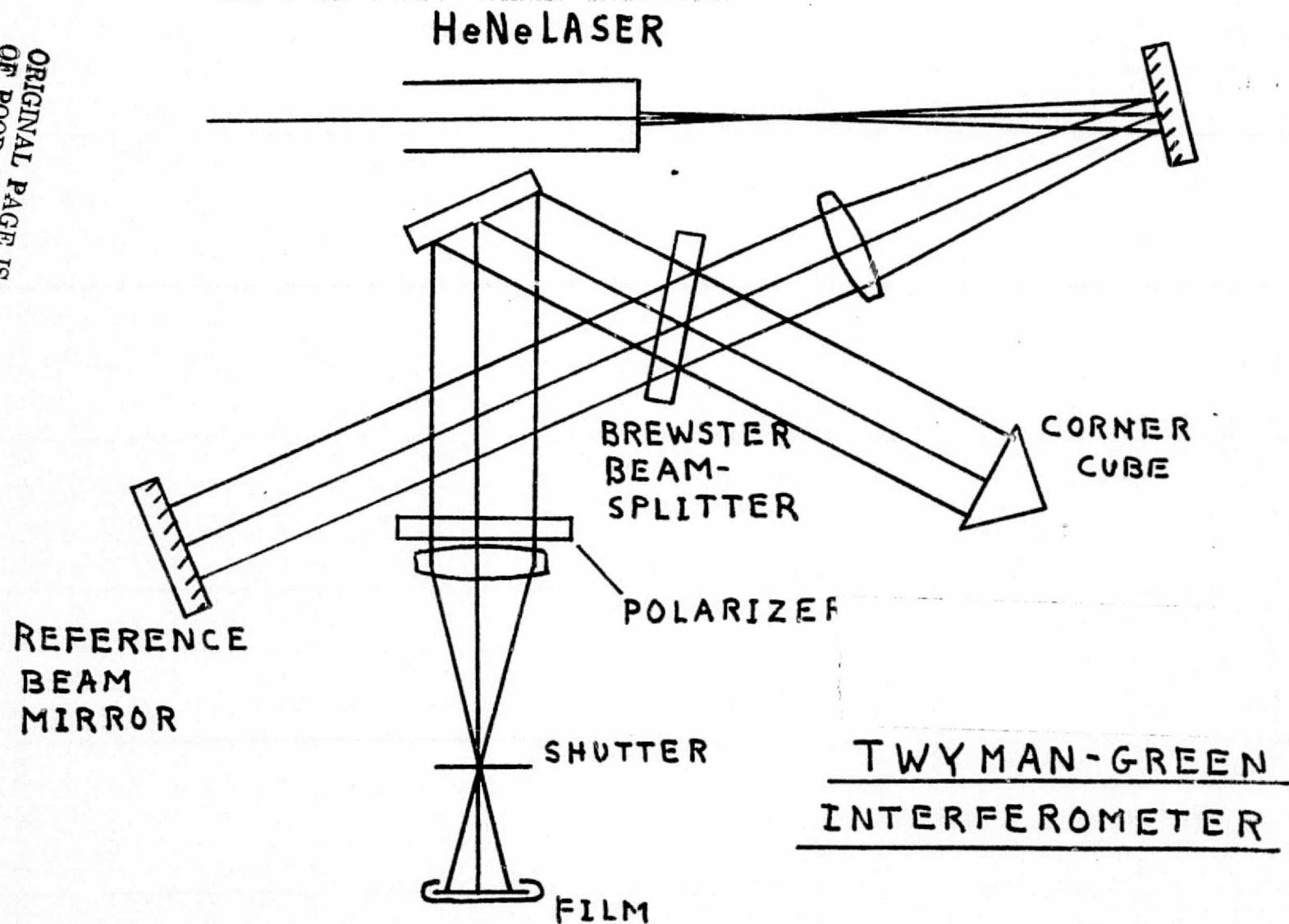
After allowing 20 minutes for the gradients in the cube to stabilize three interferograms of each of the six retroreflectors were then taken with the air wedge in each of the three interferograms parallel to a different real edge. The position of the serial number on each cube was noted relative to the interferogram. A check was made of left-to-right reversal between the cube and the interferometer (due to a possible odd number of reflections in the test equipment) as a basis for any future identification of specific cube angles. The resultant interferograms are shown in Appendix B. These interferograms were used to predict the dihedral angles and the far field patterns of the cube corners.

Data was obtained from the interferograms by measuring the positions of the centers of the dark fringes at about 100 points approximately uniformly spaced over the interferogram. This was done with a two-coordinate precision measuring engine (David W. Mann Co., Hand Comparator, model 829C) with a digital readout having least count of $1\mu\text{M}$. This was attached to an IBM model 026 card punch so that the data were obtained on punched cards directly. In general, the points were taken

FIGURE 4

TEST SETUP FOR INTERFEROMETRY OF LAGEOS CUBES # 1 - 6

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along straight scans that were approximately orthogonal to the fringes. For each point, the relative order of the fringe was noted. The major error in this kind of measurement is in the ability of the operator to locate the center of the fringe. Past experience has shown that the repeatability of these measurements is generally less than 0.01 fringe rms and can be as small as 0.002 fringe rms for high contrast interferograms with low background noise. The measured data points were then interpolated on a grid for purposes of analysis.

It should be noted that because of the finite sampling of the wavefront, high frequency variations are not measured. This is expected to have no measurable effect on the determination of dihedral angle since this quantity is determined from the gross features of the surface. The effect on the energy in the annulus of interest is expected to be less than one percent of the total energy and the predicted energy would be consistently higher than the measured energy.

Dihedral Angle Determination

In a perfect cube corner with 90 degree dihedral angles, the exiting wavefronts from each sextant are plane and are parallel to one another. In addition, they are parallel to the incident wavefront. Any deviations in the dihedral angles result in deviations of the directions of the exiting wavefronts. In addition, the exiting wavefront is radially symmetric. That is, two points which are equidistant from the center and diametrically opposite have the same phase (we are ignoring polarization effects here because they do not affect the direction of the wavefront). This is because the paths for the two rays exiting at these points are identical and thus suffer the same retardation. These considerations can be used to find the dihedral angles from a measurement of the exiting wavefront.

Assuming there are no surface errors on the reflecting surfaces, the wavefront can be defined by the OPD (Optical Path Difference) between a point on the wavefront at the center of the cube and a point on the wavefront at the edge of each of the three real edges. These values are noted in figure 5 by W_{12} , W_{13} , and W_{23} . These points are radially symmetric as previously described. These values may be obtained from an interferogram by counting the number of fringes from center to edge along each of the radial lines and taking into account the sign of the result according to whether the fringes represent increasing or decreasing path difference. The two opposite values are then averaged to cancel out the tilt in the reference beam (used to produce the fringes) and give radially symmetric results.

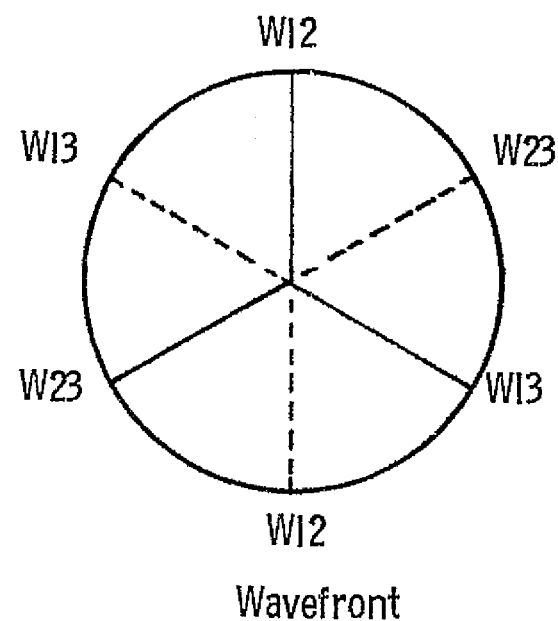
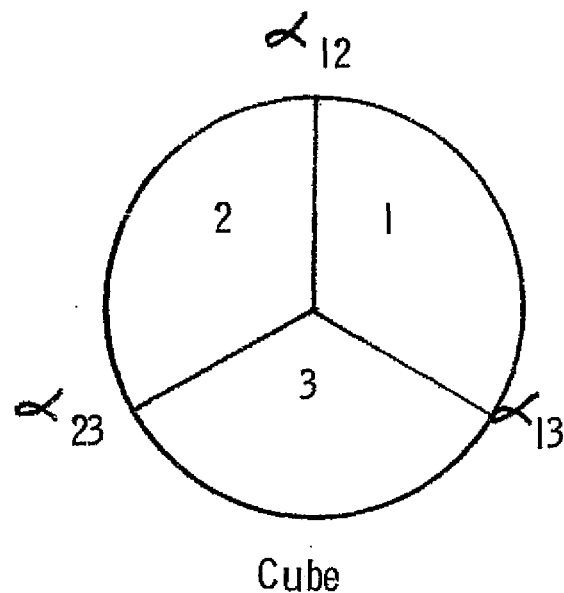
Since there are figure errors on the reflecting surfaces, the exiting wavefront sextants are not exactly plane, and thus the data reduction scheme described above cannot be used with any degree of precision. Therefore, the following procedure was used to determine the values of W_{12} , W_{13} , and W_{23} .

1. For each sextant, the fringes were digitized as described previously. This resulted in about 15-20 points in each sextant which gives OPD as a function of position.

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FIGURE 5

CALCULATION OF DIHEDRAL ANGLES FROM INTERFEROGRAM



$$\alpha_{12} = \sqrt{\frac{1}{2}} \frac{1}{nD}$$

$$\alpha_{13} = \sqrt{\frac{1}{2}} \frac{1}{nD}$$

$$\alpha_{23} = \sqrt{\frac{1}{2}} \frac{1}{nD}$$

$$[W_{13} + W_{23} - W_{12}]$$

$$[W_{23} + W_{12} - W_{13}]$$

$$[W_{12} + W_{13} - W_{23}]$$

2. A plane was fit through the measured data using least squares fitting techniques. This gives a representation of the plane wavefront which would exist if there were no errors but the dihedral angle errors.
3. The OPD at the edge of each radial line was determined from this plane. Since values could be obtained from two adjacent sextants, and since theoretically the two results should be the same, the two adjacent values were averaged.
4. Diametrically opposite values were averaged to cancel out the tilt in the reference beam and give radially symmetric results. These are the values for W_{12} , W_{13} , W_{23} .
5. The dihedral angles were found from the following relationship (See Appendix C)

$$\alpha_{12} = \frac{1}{\sqrt{2} ND} (W_{13} + W_{23} - W_{12})$$

$$\alpha_{13} = \frac{1}{\sqrt{2} ND} (W_{23} + W_{12} - W_{13})$$

$$\alpha_{23} = \frac{1}{\sqrt{2} ND} (W_{12} + W_{13} - W_{23})$$

where N is the index of refraction of the cube and D is the aperture diameter.

The dihedral angles of each cube were obtained from an average of the results obtained from the three interferograms of the cube. The values from each interferogram and the average for each dihedral angle are shown in Table 2.

In addition to the Itek measurement of the dihedral angle, mechanical measurements were made by Zygo Corporation and by Moore Special Tool Co. Also, an Itek analysis was made of interferograms produced by Zygo on cubes 1, 2, and 4. A comparison of these values are shown in Table 3. As may be seen from Table 3 the measurements may vary by as much as 0.5 arc-second. Since the interferometric analysis examines the exiting wavefront from the cube it is assumed to be more closely related to the far field performance of the cube. It is recommended, therefore, that interferometric measurement of the cube dihedral angles be used in future evaluations.

TABLE 3
COMPARISON OF DIHEDRAL ANGLE MEASUREMENTS ON CUBES 1, 2, and 4

Cube Corner I.D.#	Moore*	Itek Analysis			
		Zygo Mechanical*		Zygo** Interferograms	Itek*** Interferograms
		Operator #1	Operator #2		
1	2.14	2.10	2.05	2.44	1.95
	2.00	1.67	1.89	2.04	1.76
	1.72	1.55	1.75	1.88	1.51
2	1.68	1.33	1.63	1.98	2.03
	1.84	1.38	1.81	1.76	1.98
	1.76	1.38	1.76	0.98	1.68
4	1.82	1.68	1.46	2.02	1.85
	1.80	1.24	1.30	1.31	1.75
	1.80	1.23	1.41	1.65	1.85

* The mechanically measured angles are based on five (5) measurements of each cube corner.

** Based on Itek analysis of one interferogram

*** Based on Itek analysis of three interferograms.

Far Field Pattern

The interferograms produced in the Twyman Green Interferometer were also used to predict the far field pattern of each cube. The procedure used was to evaluate the wavefronts from the three interferograms of each carefully aligned cube and average them to obtain the component of the wavefront parallel to the input beam (Q polarization). The theoretical phase shift due to polarization alone was then subtracted from this average wavefront to obtain the resultant surface error and dihedral angles. By adding the theoretical phase shift of the perpendicular component (P polarization) of the wavefront to the resultant wavefront, the perpendicular component of the wavefront of that cube was obtained.

The phase shift from sextant to sextant for the Q polarization was obtained from the evaluation of the interferograms and compared with the theoretical phase shift. As seen from Figure 6 the interferometric measurement of the phase shift agreed with the theoretical phase shift within $\pm 0.02\lambda$ as measured at a wavelength of 0.6328μ . A separate analysis showed that phase shift errors of this magnitude have no discernible effect on the far field pattern.

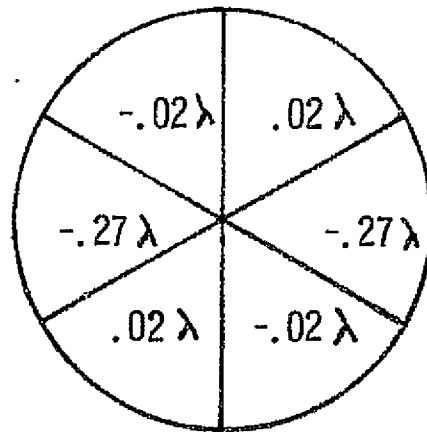
The far field patterns of the P and Q polarizations were then calculated from the wavefronts using the theoretical amplitude variations and added to give the total far field pattern. The computer output for cubes number 1 - 6 are given in Appendix A.

The primary values of interest are the encircled energy in the 13.2 - 16.9 arc-second annulus and the apparent annulus centroid diameter of the far field pattern. These values are tabulated in Table 4. The analytically predicted encircled energy in the 13.2 - 16.9 arc second annulus for each cube is plotted on Figure 7 at the cube average dihedral angle predicted by Itek's interferometric analysis. These values are noted by the dotted circles (\odot). Also plotted on Figure 7 are the measurements of the encircled energy by Bendix. These are noted by the dotted triangles (\triangle) and are plotted at the cube average dihedral angle predicted by Itek's interferometric analysis. In all of the six cubes the measured encircled energy is lower than the analytically predicted encircled energy.

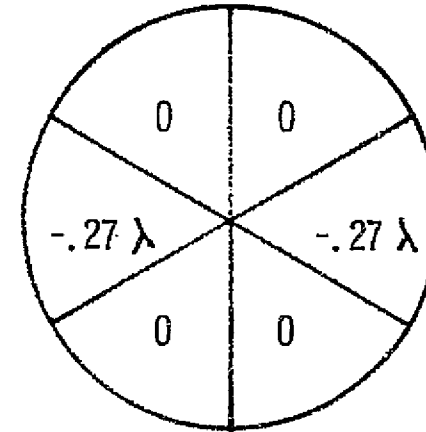
FIGURE 6

PHASE SHIFT DUE TO POLARIZATION

Q POLARIZATION
(cf. Text)



Interferometric
Measurement
($1\sigma = .02\lambda$)



Theoretical

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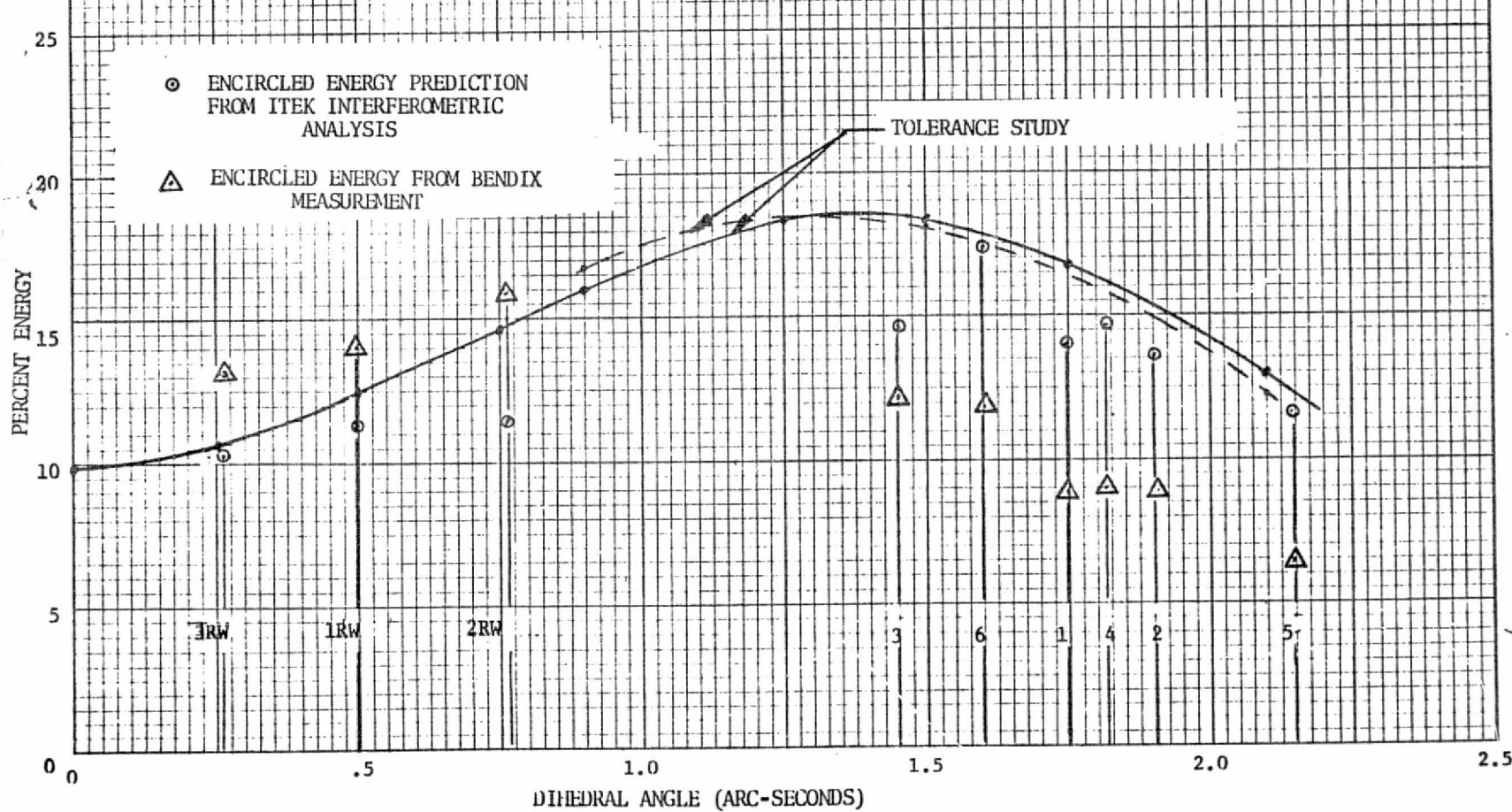
TABLE 4

FAR FIELD CHARACTERISTICS OF LAGEOS
RETROREFLECTOR - ON-AXIS

<u>Cube#</u>	Percent Energy 13.2 - 16.9 Arc-Sec		Annulus Diameter (Arc-Sec)	
	<u>Itek</u> <u>Interferogram</u>	<u>Bendix</u> <u>Measurement</u>	<u>Itek</u> <u>Interferogram</u>	<u>Bendix</u> <u>Measurement</u>
1	14.0	8.9	18.6	22.0
2	13.6	8.9	20.2	19.8
3	14.7	12.4	16.4	17.6
4	14.6	9.0	18.6	20.6
5	11.7	6.7	21.9	23.5
6	17.4	12.0	16.6	18.4
AVERAGE	14.3	9.7	18.3	20.3

FIGURE 7

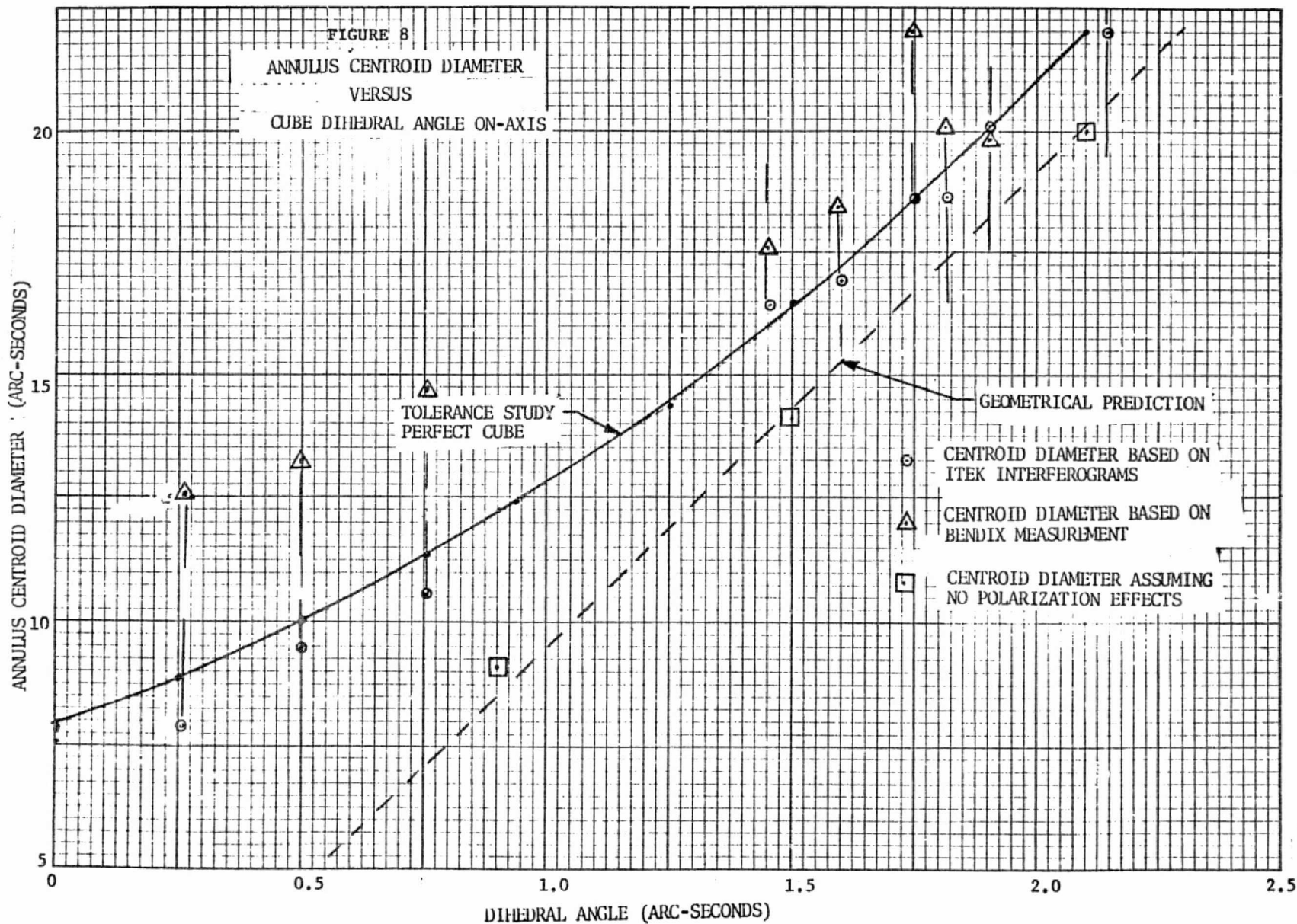
PERCENT ENERGY IN 13.2-16.9 ARC-SECOND ANNULUS
VERSUS
CUBE DIHEDRAL ANGLE ON-AXIS



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The analytically predicted annulus centroid diameter was determined by estimating the position of the maximum slopes of the encircled energy curves of the cube corners. These values are plotted at the Itek predicted cube average dihedral angle in Figure 8 and are noted by the dotted circles (\odot). The Bendix measurements of the annulus centroid diameter are noted by the dotted triangles (\triangle) in Figure 8. The measured annulus centroid diameters for the majority of the cubes are larger than the analytically predicted diameters.

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Cube Rework

The tolerance study (Figure 1) indicated the peak encircled energy in the 13.2 - 16.9 arc-second annulus occurs with a dihedral angle of about 1.35 arc-seconds. The average dihedral angle of the six cubes was 1.8 arc-seconds with the smallest value being 1.44 arc-seconds. Since no data was available at dihedral angles below 1.35 arc-seconds, three of the original cubes were reworked by Zygo to attempt to obtain cube average dihedral angles of 0.75, 1.00 and 1.25 arc-seconds.

Three interferograms of the reworked cubes were taken by Zygo and sent to Itek for analysis. In these interferograms the input beam to the cube was linearly polarized with the direction of polarization parallel to a different real edge for each interferogram, (i.e. the cube was rotated 120° after each interferogram and before the subsequent interferogram). The interferograms for the three reworked cubes are shown in Appendix B. The dihedral angles were determined using Itek's interferometric analysis and are shown in Table 5. The average cube dihedral angles were 0.23, 0.49 and 0.76 sec as based upon Itek interferometry. (Mechanical measurements showed a consistent 0.5 arc-sec bias relative to the interferometric data reduction).

In order to analyze the far field pattern of the reworked cubes, the wavefront calculated from each of the interferograms of a cube were averaged. This cancelled out the phase shift due to polarization resulting in the effects only due to surface errors and dihedral angles. The theoretical phase shifts for the P and Q polarizations were each added to the resultant average wavefront to obtain the exiting P and Q wavefronts. The computer output for the analysis of the reworked cubes is given in Appendix A.

The encircled energy in the 13.2 - 16.9 sec annulus and apparent annulus centroid diameter resulting from the Itek analysis and from Bendix measurements are shown in Table 6. The encircled energy in the 13.2 - 16.9 arc-second annulus is also plotted in Figure 7 as denoted by the dotted circles (\odot) for the Itek analysis and dotted triangles (\triangle) for the Bendix measurements. In this case the encircled energy in the Bendix measurement was lower than the Itek analysis. Since the larger dihedral angles show smaller measurements and the smaller dihedral angles show larger measured data, the annulus diameter is possibly incorrect in either the Itek annulus assumptions or in the Bendix measurement.

TABLE 5
INTERFEROMETRIC MEASUREMENT OF DIHEDRAL ANGLES
ON REWORKED CUBES (ARC-SEC)

REWORKED CUBE	INTERFEROGRAM												Ave.
	1			2			3			Average			
1	.73	.30	.45	.79	.38	.33	.83	.28	.30	.78	.32	.36	.49
2	.67	.89	.77	.58	.91	.73	.91	.79	.59	.72	.86	.70	.76
3	.28	.17	.40	.24	.30	.16	.25	.26	.30	.26	.24	.29	.26

BASED ON INTERFEROGRAM PRODUCED BY ZYGO AND ANALYZED BY ITEK

TABLE 6
FAR FIELD CHARACTERISTICS OF
REWORKED CUBES ON AXIS

REWORKED CUBE	PERCENT ENERGY 13.2 - 16.9 ARC SEC		CENTROID DIAMETER (ARC-SEC)	
	ITEK INTERFEROGRAM	BENDIX MEASUREMENT	ITEK INTERFEROGRAM	BENDIX MEASURED
1	11.35	14.0	9.4	13.2
2	11.5	16.0	10.5	14.7
3	10.4	13.0	7.9	12.5

BASED ON INTERFEROGRAM PRODUCED BY ZYGO AND ANALYZED BY ITEK

If the annulus were smaller than assumed the deviations shown in Figure 7 would occur. To this date the discrepancy has not been resolved.

The apparent annulus centroid diameters for the reworked cubes are noted in Figure 8 by dotted circles (\odot) for the Itek analysis and dotted triangles (\triangle) for the Bendix measurement. The Bendix measurements indicate a much larger annulus centroid diameter than the assumed value in the Itek analysis. This conclusion agrees with the conclusion arrived at from the encircled energy data.

Summary/Recommendations

One purpose of this study was to resolve apparent contradictions between experimental test results and simplified geometrical predictions. A major portion of the differences was caused by polarization effects. A smaller contradiction still exists between the analysis and test. This difference may be caused by a test annulus which is smaller than assumed. This discrepancy has not as yet been resolved.

Another purpose of the study was to recommend a cube dihedral angle that produces the maximum energy in the 13.2 - 16.9 arc-second annulus. Based upon Figure 25, a cube with all dihedral angles the same would produce the maximum energy with a 1.35 arc second annulus. Since variations in dihedral angles tend to spread the energy (Figure 25) a better choice for average dihedral angles would be 1.25 arc-seconds.

A discrepancy was also noted between interferometric measurements of the dihedral angles and mechanical measurements. Since the interferometric measurements measure the output from the cube while the mechanical measurements are taken on the back faces of the cube it is recommended that interferometric measurements be used in determining cube dihedral angles, as the results should tie more closely to far field performance.

APPENDIX A

Computer Output of Cases Analyzed

This appendix includes the computer output resulting from the tolerance analyses and the cube interferometric analyses. Table A1 provides a reference for locating figures and tables that apply to different cases.

The tolerance study for cubes with all dihedral angles the same are shown in Figures A1 - A24 and Tables A2 - A7. The off-nominal cube with dihedral angle variations of 0.0, + 0.5 arc sec and - 0.5 sec discussed in the text of the report are given in Figures A25 - A32 and Tables A8 and A9. Also included in this appendix but not shown in Table A1 were encircled energy tables for dihedral angles of 0.0, 0.25, 0.5 and 0.75 sec . There are shown in Tables A10 and A11, Tables A12 and A13, Tables A14 and A15, and Tables A16 and A17 respectively.

The computer output resulting from the interferometric analysis of the six initial cubes are shown in Figures A33 - A80 and Tables A18 - A29. The three cubes that were reworked after an analysis of the six initial cubes are shown in Figures A81 - A104 and Tables A30 - A35.

TABLE A1

Figure numbers and tables that give the performance of the specified cases

Case	Wavefront Maps	Wavefront Plots	Intensity Maps	Intensity Plots	Encircled Energy Plots	Encircled Energy Tables
0.9 arc-second nominal cube	Fig. No.: A1, A3	Fig. No.: A2, A4	Fig. No.: A5	Fig. No.: A6, A7	Fig. No.: A8	Table No.: A2, A3
1.25 arc second nominal cube	A9, A11	A10, A12	A13	A14, A15	A16	A4, A5
1.75 arc second nominal cube	A17, A19	A18, A20	A21	A22, A23	A24	A6, A7
0.9 arc second nominal cube	A25, A27	A26, A28	A29	A30, A31	A32	A8, A9
Cube #1	A33, A35	A34, A36	A37	A38, A39	A40	A18, A19
Cube #2	A41, A43	A42, A44	A48	A46, A47	A48	A20, A21
Cube #3	A49, A51	A50, A52	A53	A54, A55	A56	A22, A23
Cube #4	A57, A59	A58, A60	A61	A62, A63	A64	A24, A25
Cube #5	A65, A67	A66, A68	A69	A70, A71	A72	A26, A27
Cube #6	A73, A75	A74, A76	A77	A78, A79	A80	A28, A29
Cube #1RW	A81, A83	A82, A84	A85	A86, A87	A88	A30, A31
Cube #2RW	A89, A91	A90, A92	A93	A94, A95	A96	A32, A33
Cube #3RW	A97, A99	A98, A100	A101	A102, A103	A104	A34, A35

0.9 Arc-Second Nominal Cube

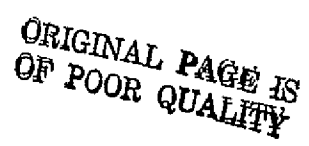
Wavefront Map - Q Polarization

MAP IN UNITS OF 0.01 WAVES

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0.9 Arc-Second Nominal Cube



0.9 Arc-Second Nominal Cube

MAP IN UNITS OF 0.01 WAVES

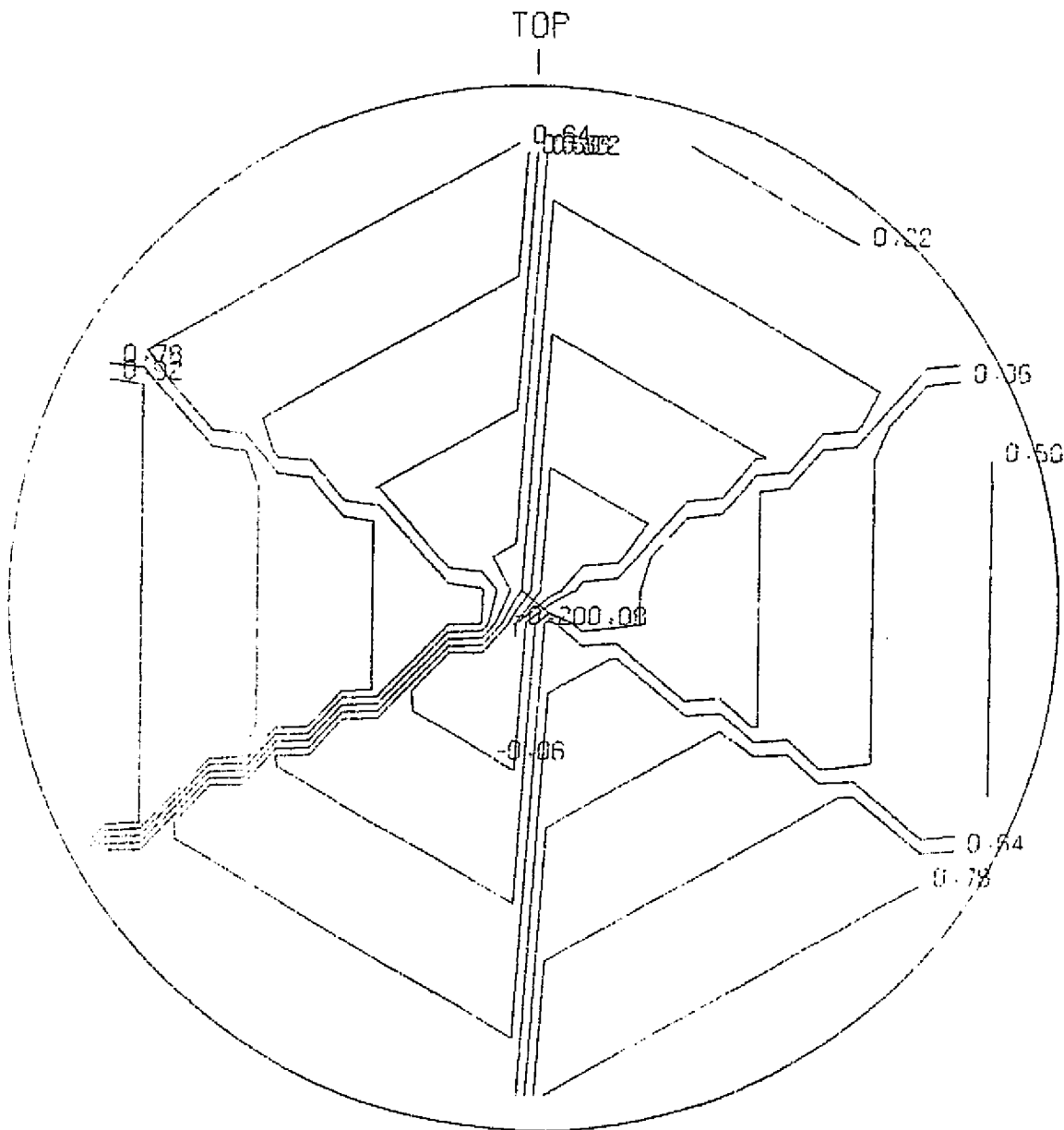
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Figure A4

A6

0.9 Arc-Second Nominal Cube
Wavefront Plot - P Polarization

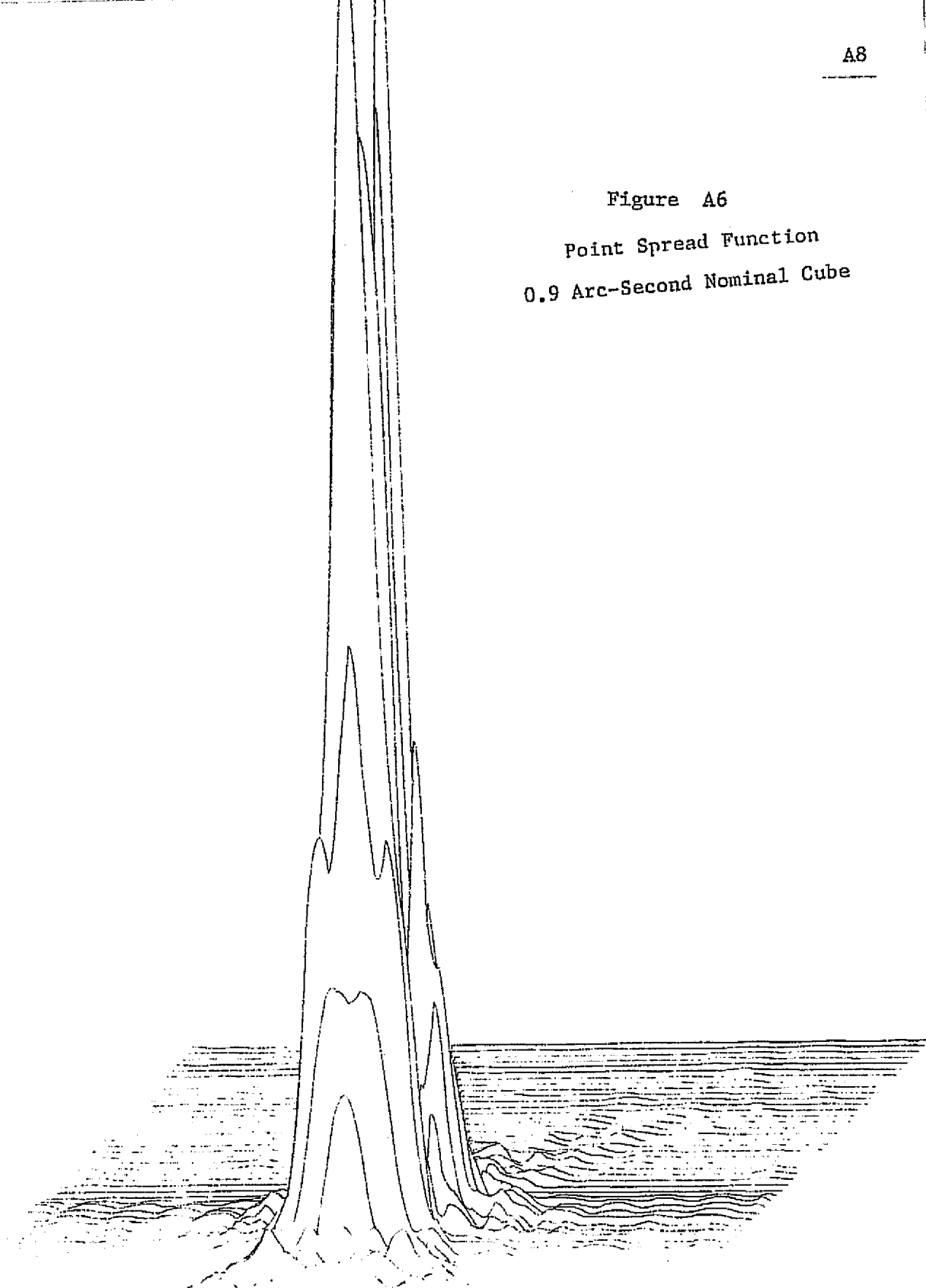


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34

Figure A6
Point Spread Function
0.9 Arc-Second Nominal Cube

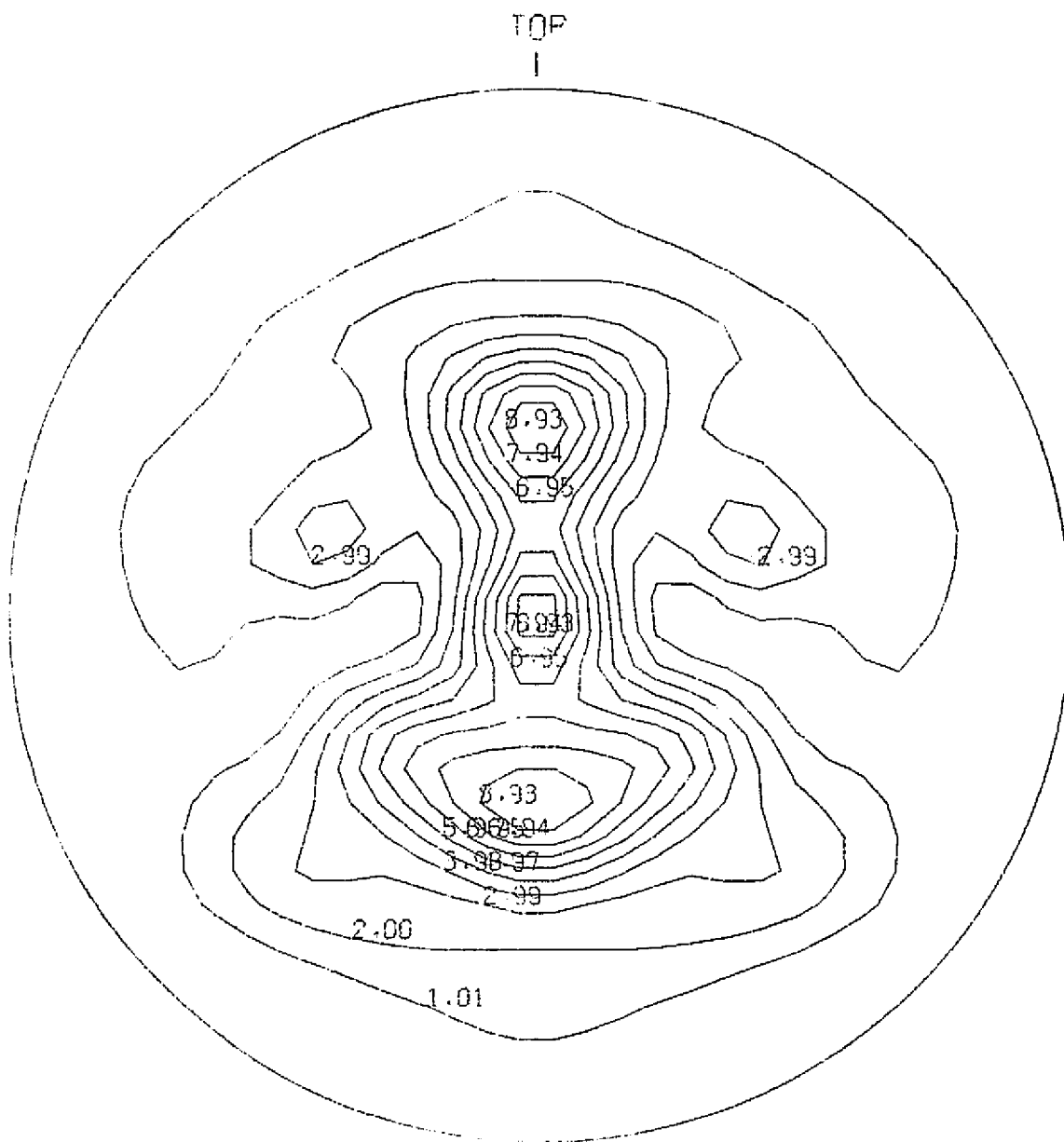


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Figure A7

0.9 Arc-Second Nominal Cube

Intensity Distribution - Central 129 Microradians

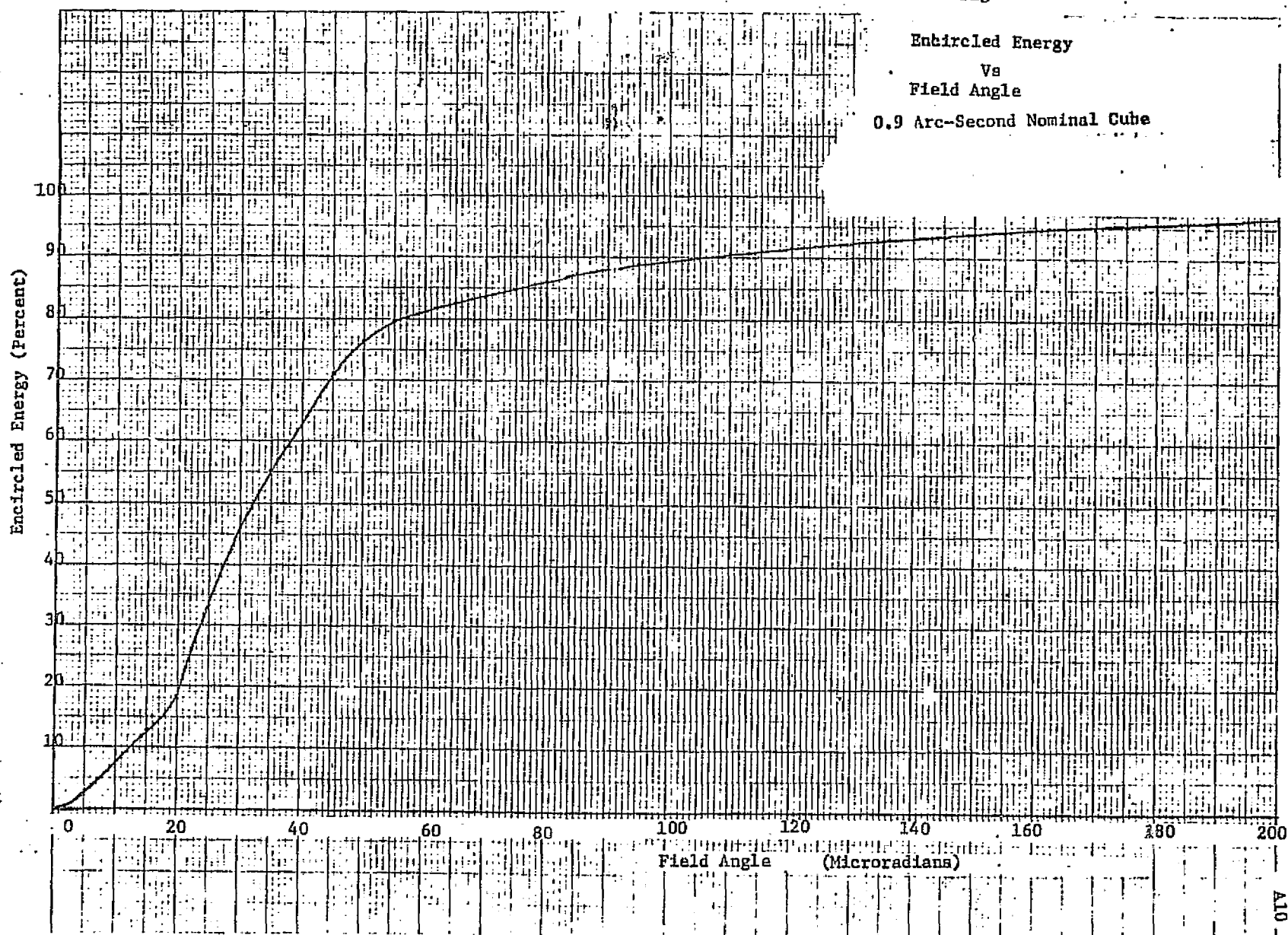


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Figure A8

Encircled Energy
Vs
Field Angle

0.9 Arc-Second Nominal Cube



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Table A2

A11

ENCIRCLED ENERGY

0.9 Arc-Second Nominal Cube

CIRCLE

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

RADIUS

(MIL-)

CENTER (MICRONS):

CROSS)

X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13

2.00	0.0	0.0	0.4	0.1	0.6	0.1	0.4	0.0	0.0
4.00	0.6	0.6	0.8	0.3	0.6	0.3	0.8	1.1	1.1
6.00	1.6	1.6	2.5	1.0	4.1	1.0	2.7	1.1	1.1
8.00	2.3	2.3	4.6	2.4	4.1	2.4	4.9	3.6	3.6
10.00	3.2	3.2	5.9	3.1	7.6	3.1	6.7	4.9	4.8
12.00	7.5	7.5	9.3	5.7	8.5	5.7	10.6	9.9	9.9
14.00	7.5	7.5	11.5	8.9	11.2	8.9	14.3	9.9	9.9
16.00	12.9	12.9	15.0	11.6	13.0	11.6	18.2	15.7	15.6
18.00	15.2	15.2	17.1	15.2	18.7	15.2	21.3	18.3	18.2
20.00	19.3	19.3	21.6	19.1	18.7	19.1	26.1	22.5	22.5
22.00	21.5	21.5	23.9	24.1	26.4	24.1	28.8	25.0	25.0
24.00	26.2	26.2	27.2	26.5	29.5	26.5	32.0	29.8	29.8
26.00	28.4	28.3	30.4	32.3	37.1	32.2	34.7	32.3	32.3
28.00	33.2	33.2	35.3	37.5	39.0	37.5	39.6	36.9	36.8
30.00	36.5	36.5	38.6	42.3	45.8	42.3	41.8	40.5	40.5
32.00	42.7	42.7	43.3	45.9	48.5	45.9	46.3	46.0	46.0
34.00	43.9	43.8	47.0	51.2	52.6	51.1	49.5	47.3	47.3
36.00	50.2	50.2	51.9	54.6	56.1	54.6	54.4	52.7	52.7
38.00	52.9	52.9	55.3	58.3	60.2	58.3	57.0	55.2	55.2
40.00	57.3	57.3	59.3	61.4	62.3	61.4	61.2	59.2	59.2
42.00	59.7	59.7	62.6	64.9	66.6	64.9	64.1	61.3	61.3
44.00	63.7	63.7	65.1	66.5	69.0	66.5	66.9	64.9	64.9
46.00	66.0	66.0	67.9	69.5	72.7	69.5	69.4	67.1	67.1
48.00	68.8	68.8	70.6	71.8	73.7	71.8	71.9	69.9	69.9
50.00	70.9	70.9	72.4	73.4	76.4	73.4	73.3	71.9	71.9
52.00	73.1	73.1	74.7	75.4	77.4	75.4	75.4	73.8	73.8
54.00	74.4	74.4	76.5	76.9	78.9	76.9	76.7	75.1	75.1
56.00	76.6	76.6	78.5	78.6	79.6	78.6	78.3	76.8	76.8
58.00	78.0	78.0	79.5	79.4	80.6	79.4	79.2	78.1	78.1
60.00	79.4	79.4	80.7	80.5	81.2	80.5	80.3	79.2	79.2
62.00	80.3	80.3	81.4	81.2	81.8	81.2	81.0	80.1	80.1
64.00	81.5	81.5	82.0	81.8	82.4	81.8	81.7	81.2	81.2
66.00	82.2	82.2	82.6	82.5	82.9	82.5	82.5	82.0	82.0
68.00	82.9	82.9	83.1	83.0	83.2	83.0	83.1	82.8	82.8
70.00	83.3	83.3	83.6	83.5	83.7	83.5	83.7	83.3	83.3
72.00	84.0	84.0	84.0	84.0	84.1	84.0	84.2	84.0	84.0
74.00	84.3	84.3	84.5	84.6	84.6	84.6	84.8	84.4	84.4
76.00	84.9	84.9	84.9	85.1	85.0	85.1	85.3	85.0	85.0
78.00	85.3	85.3	85.3	85.5	85.6	85.5	85.6	85.5	85.5
80.00	85.7	85.7	85.7	85.9	86.0	85.9	86.0	85.9	85.9

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Table A3

ENCIRCLED ENERGY

0.9 Arc-Second Nominal Cube

CIRCLE *
----- * PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES
RADIUS *
----- *

(MI- * CENTER (MICRONS):
CRONS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13
* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13
*

5.00	*	0.6	0.6	2.0	1.0	2.5	1.0	2.2	1.1	1.1
10.00	*	3.2	3.2	5.9	3.1	7.6	3.1	6.7	4.9	4.8
15.00	*	11.3	10.8	14.4	10.4	13.0	10.4	17.1	13.3	13.3
20.00	*	19.3	19.3	21.6	19.1	18.7	19.1	26.1	22.5	22.5
25.00	*	27.7	27.6	29.4	31.7	33.1	31.6	34.1	31.4	31.4
30.00	*	36.5	36.5	38.6	42.3	45.8	42.3	41.8	40.5	40.5
35.00	*	47.9	47.9	49.8	52.1	55.2	52.1	51.8	50.4	50.4
40.00	*	57.3	57.3	59.3	61.4	62.3	61.4	61.2	59.2	59.2
45.00	*	65.0	65.0	66.7	68.5	71.1	68.5	68.3	66.3	66.3
50.00	*	70.9	70.9	72.4	73.4	76.4	73.4	73.3	71.9	71.9
55.00	*	75.8	75.8	77.6	77.9	79.4	77.9	77.7	76.1	76.1
60.00	*	79.4	79.4	80.7	80.5	81.2	80.5	80.3	79.2	79.2
65.00	*	81.8	81.8	82.4	82.2	82.7	82.2	82.2	81.6	81.6
70.00	*	83.3	83.3	83.6	83.5	83.7	83.5	83.7	83.3	83.3
75.00	*	84.6	84.6	84.7	84.9	84.8	84.9	85.0	84.8	84.8
80.00	*	85.7	85.7	85.7	85.9	86.0	85.9	86.0	85.9	85.9
85.00	*	86.7	86.7	86.9	87.1	87.3	87.1	87.0	86.8	86.8
90.00	*	87.6	87.6	87.9	88.0	88.2	88.0	87.9	87.7	87.7
95.00	*	88.6	88.6	88.7	88.7	88.9	88.7	88.6	88.5	88.5
100.00	*	89.3	89.3	89.4	89.3	89.5	89.3	89.3	89.2	89.2
105.00	*	89.3	89.8	90.0	89.9	89.9	89.9	90.0	89.8	89.8
110.00	*	90.4	90.4	90.4	90.4	90.5	90.4	90.6	90.5	90.5
115.00	*	90.9	90.9	90.8	91.0	91.0	91.0	91.0	91.0	91.0
120.00	*	91.3	91.3	91.3	91.5	91.5	91.5	91.4	91.4	91.4
125.00	*	91.8	91.8	91.9	91.9	91.9	91.9	91.9	91.8	91.8
130.00	*	92.2	92.2	92.3	92.2	92.3	92.2	92.3	92.2	92.2
135.00	*	92.6	92.6	92.6	92.6	92.7	92.6	92.6	92.6	92.6
140.00	*	93.0	93.0	93.0	93.0	92.9	93.0	93.0	92.9	92.9
145.00	*	93.3	93.3	93.3	93.3	93.2	93.3	93.2	93.2	93.2
150.00	*	93.6	93.6	93.6	93.6	93.7	93.6	93.6	93.6	93.6
155.00	*	93.9	93.9	93.9	93.9	94.0	93.9	93.9	93.9	93.9
160.00	*	94.2	94.2	94.2	94.3	94.3	94.3	94.2	94.2	94.2
165.00	*	94.5	94.5	94.6	94.6	94.6	94.6	94.6	94.6	94.6
170.00	*	94.8	94.8	94.8	94.8	94.9	94.8	94.9	94.8	94.8
175.00	*	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1
180.00	*	95.4	95.4	95.3	95.4	95.4	95.4	95.3	95.3	95.3
184.99	*	95.6	95.6	95.5	95.6	95.6	95.6	95.5	95.6	95.6
189.99	*	95.8	95.8	95.9	95.8	95.9	95.8	95.9	95.8	95.8
194.99	*	95.0	96.0	96.1	96.0	96.1	96.0	96.1	96.0	96.0
199.99	*	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3

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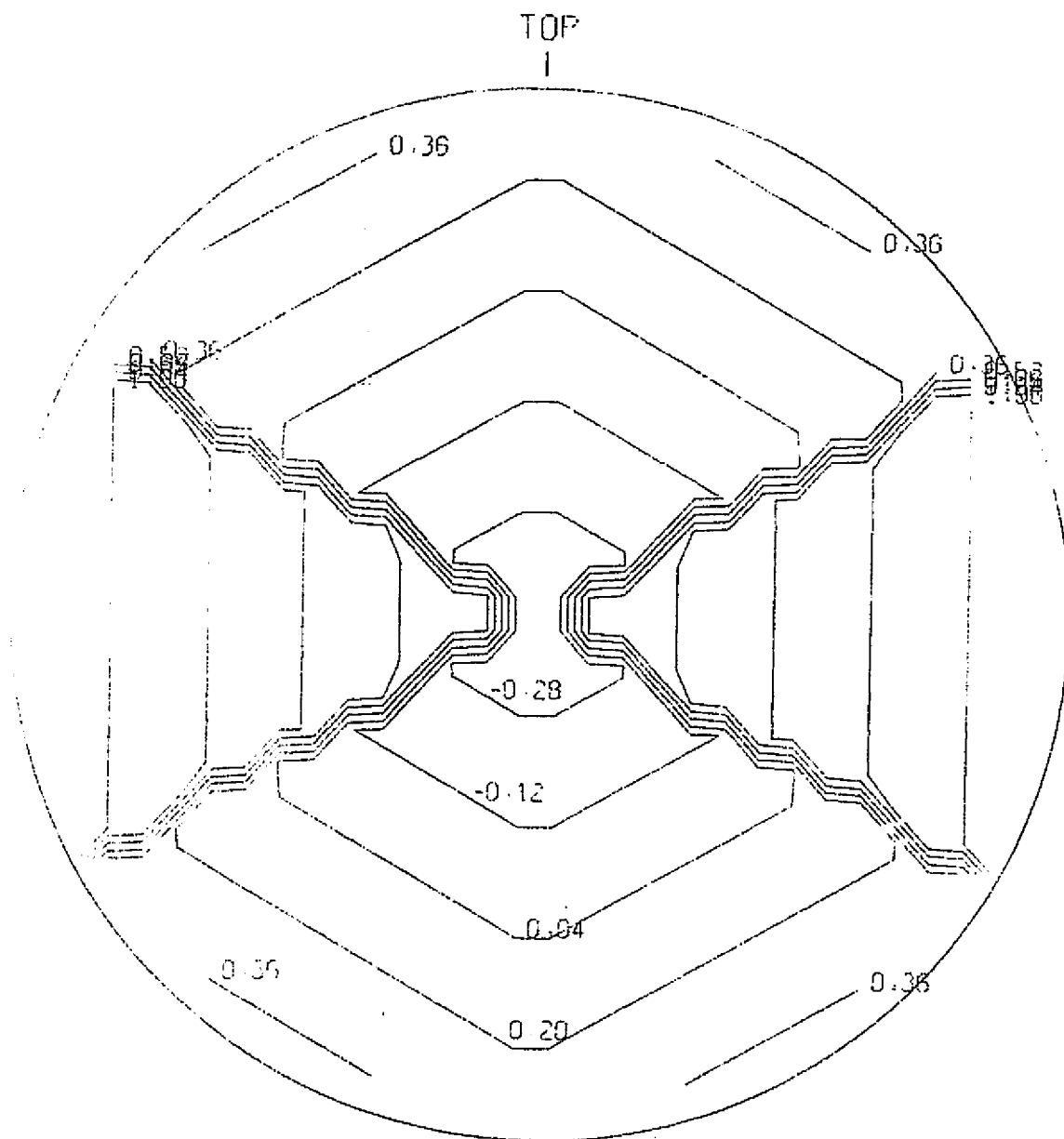
Figure A9
Wavefront Map - Q Polarization
1.25 Arc-Second Nominal Cube

MAP IN UNITS OF 0.01 WAVES

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Figure A10

Wavefront Plot - Q Polarization
1.25 Arc-Second Nominal Cube



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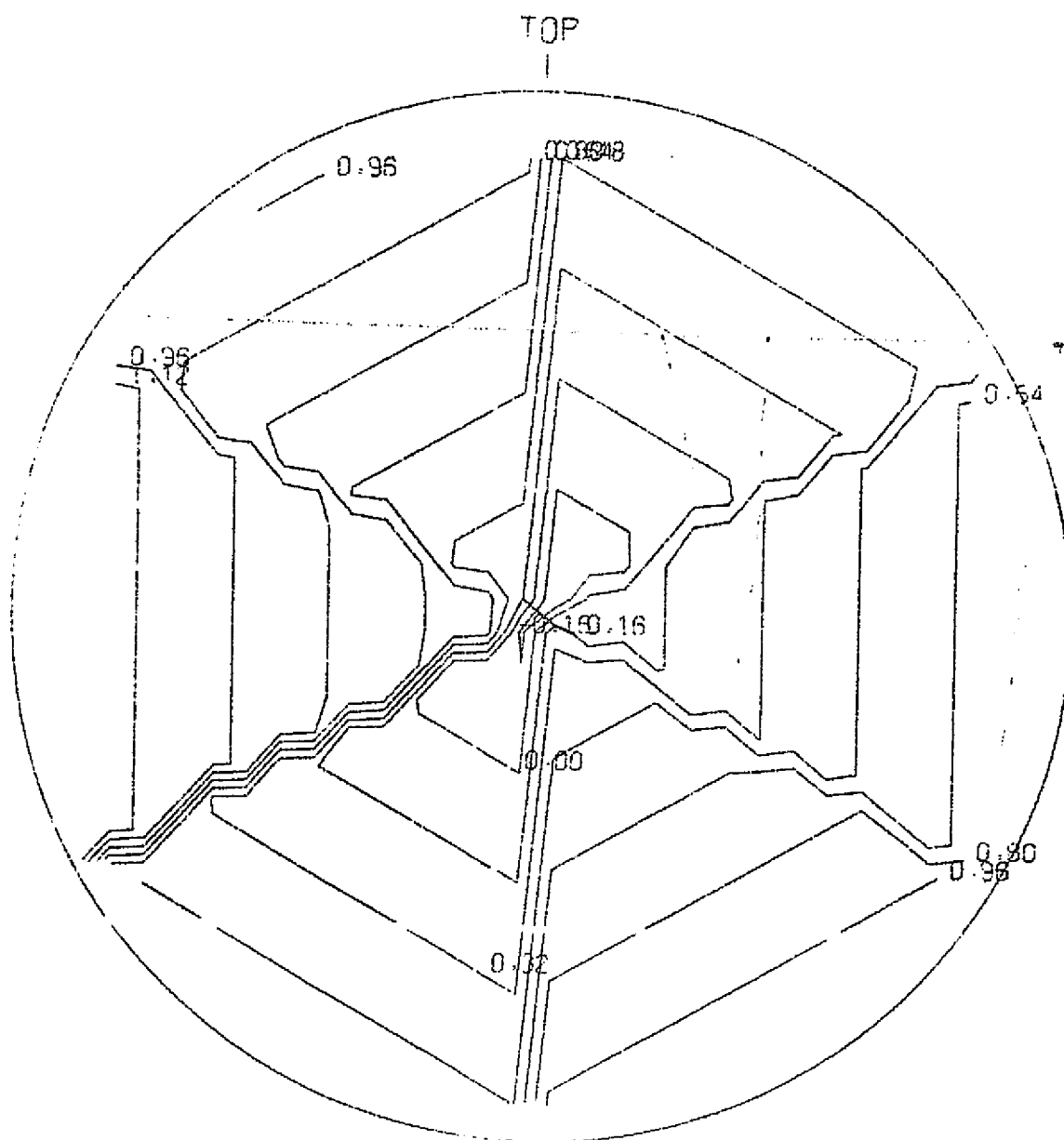
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Figure: A12

Wavefront Plot - P Polarization
1.25 Arc-Second Nominal Cube



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Figure A13

PRINTER MAP OF POINT SPREAD FUNCTION

1.25 Arc-Second Nominal Cube

IONE SPACE REPRESENTS 0.04 MICRONS

NORMALIZED SD LARGEST VALUE = 0.0392 = 100

TOTAL ENERGY = 0.2461000D+01

MAP REPRESENTS 0.2315001D+01 OF 94.0675 PERCENT OF TOTAL ENERGY

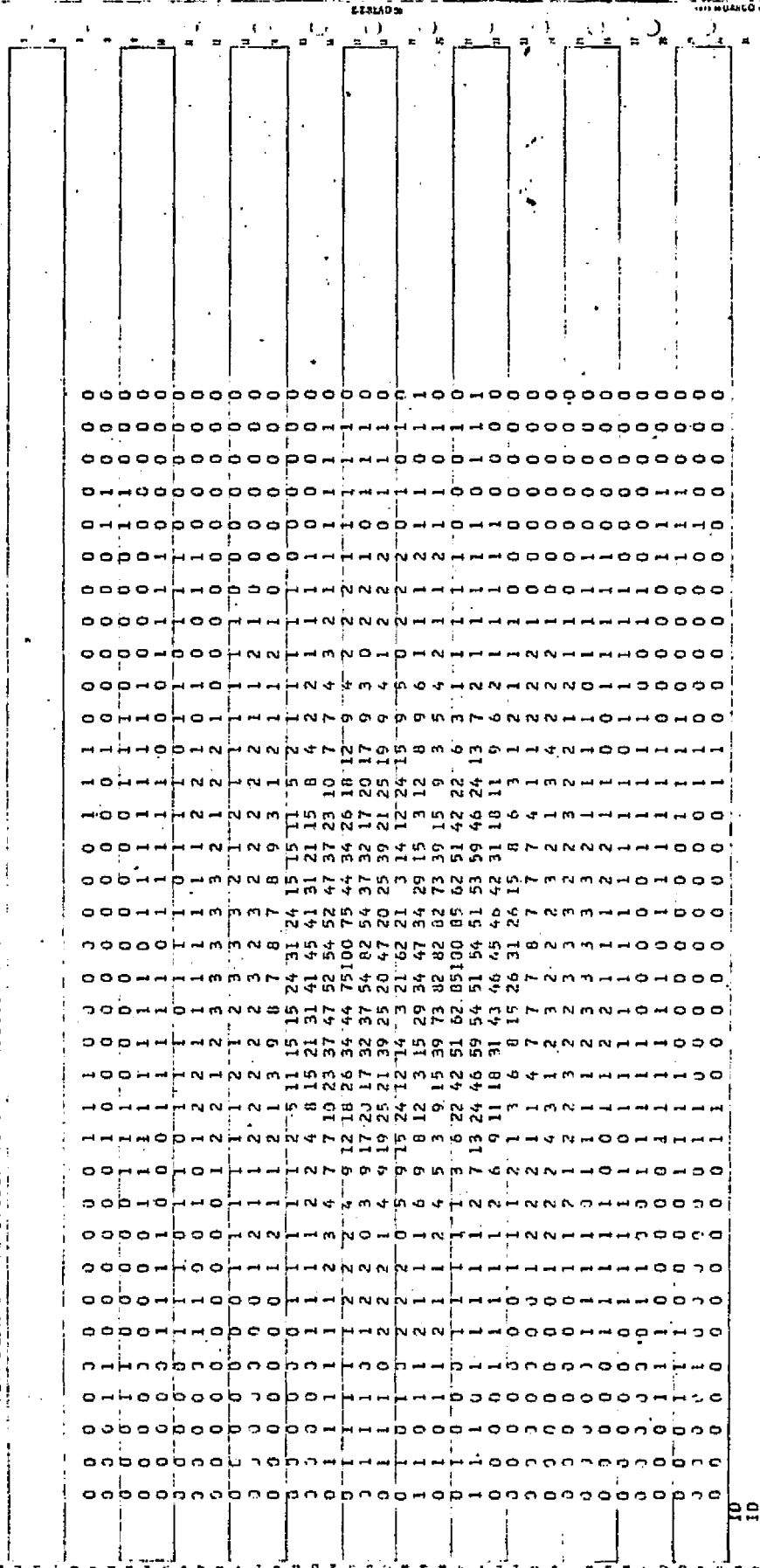
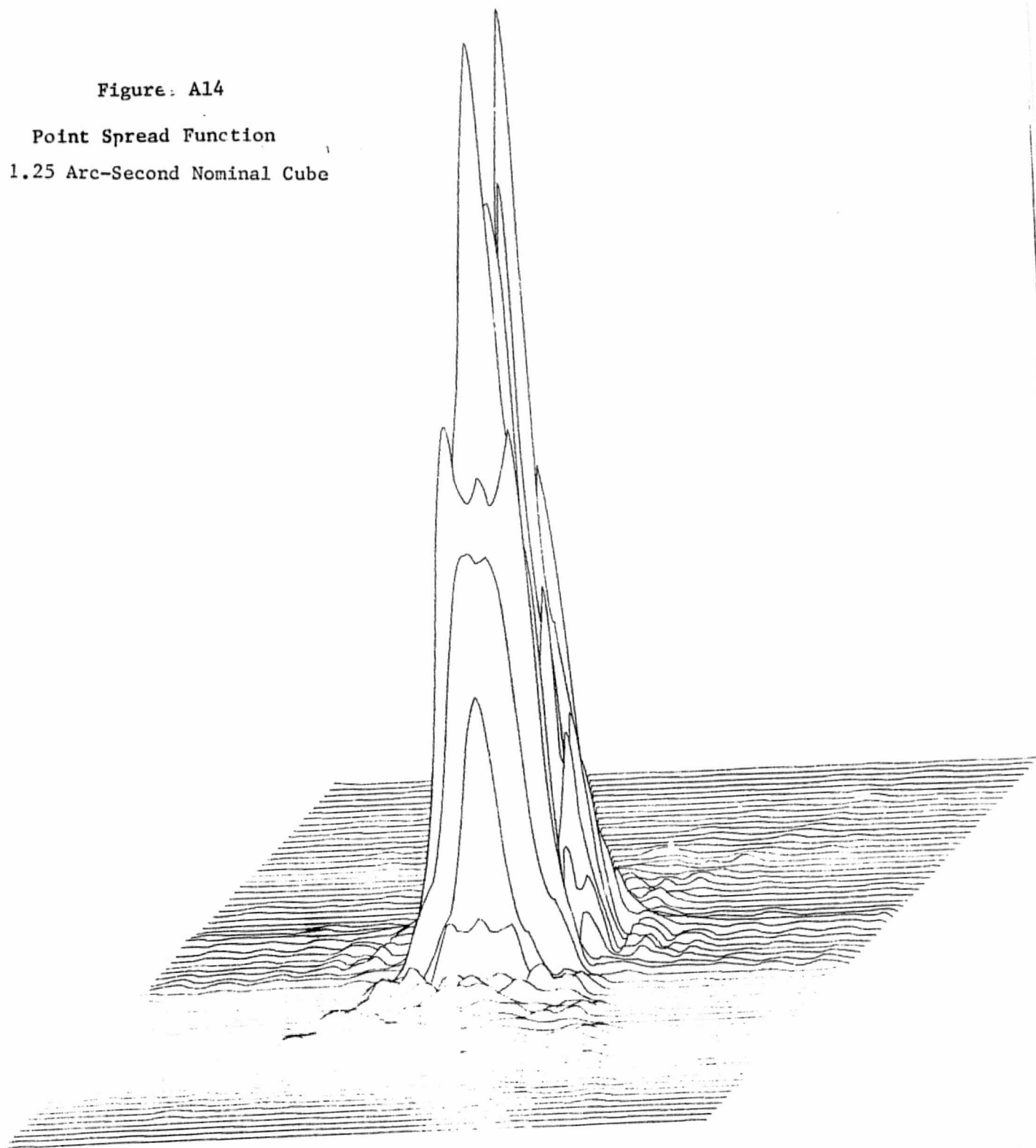


Figure: A14

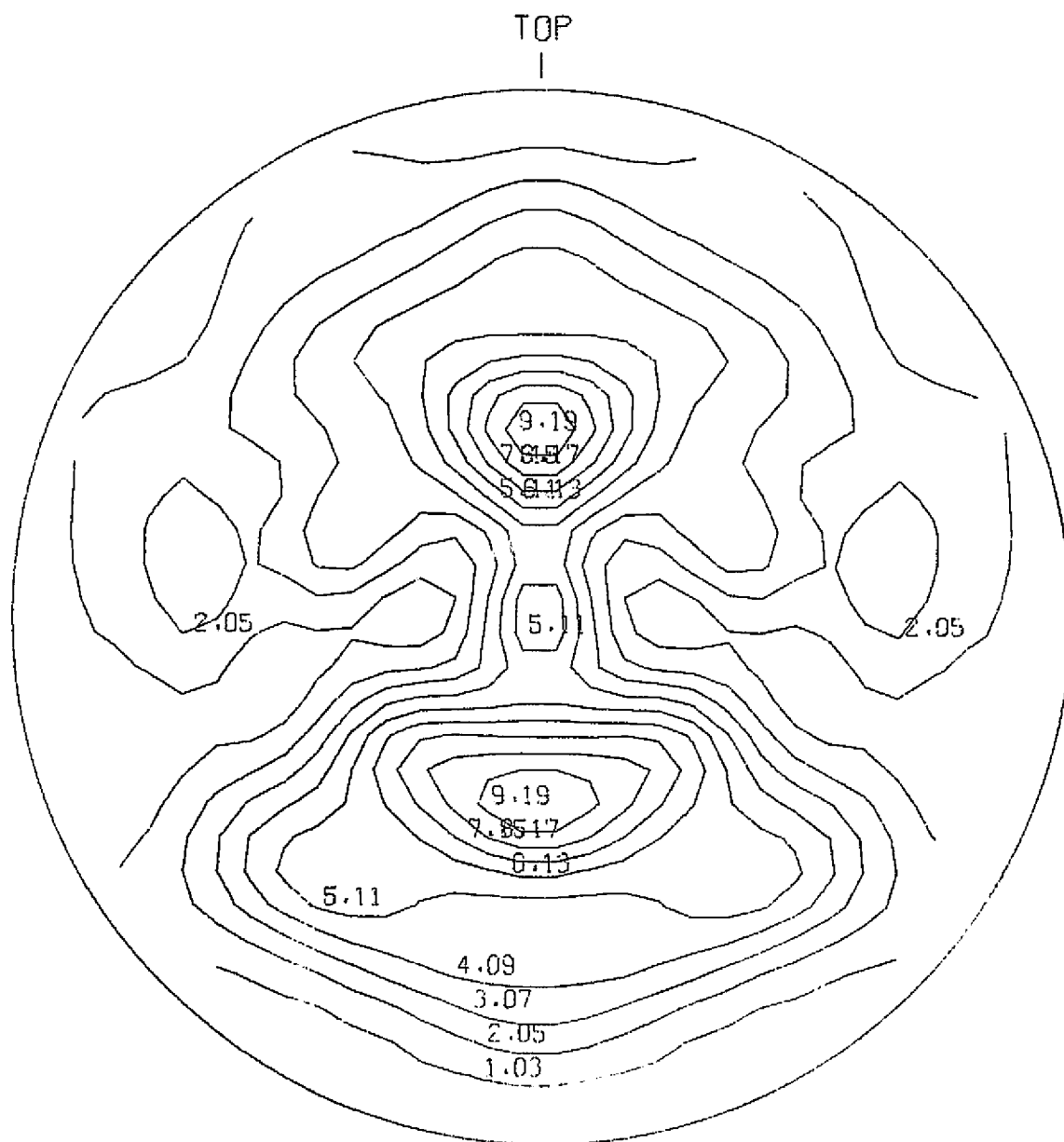
Point Spread Function
1.25 Arc-Second Nominal Cube



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Figure A15

Intensity Distribution - Central 129 Microradians
1.25 Arc-Second Nominal Cube



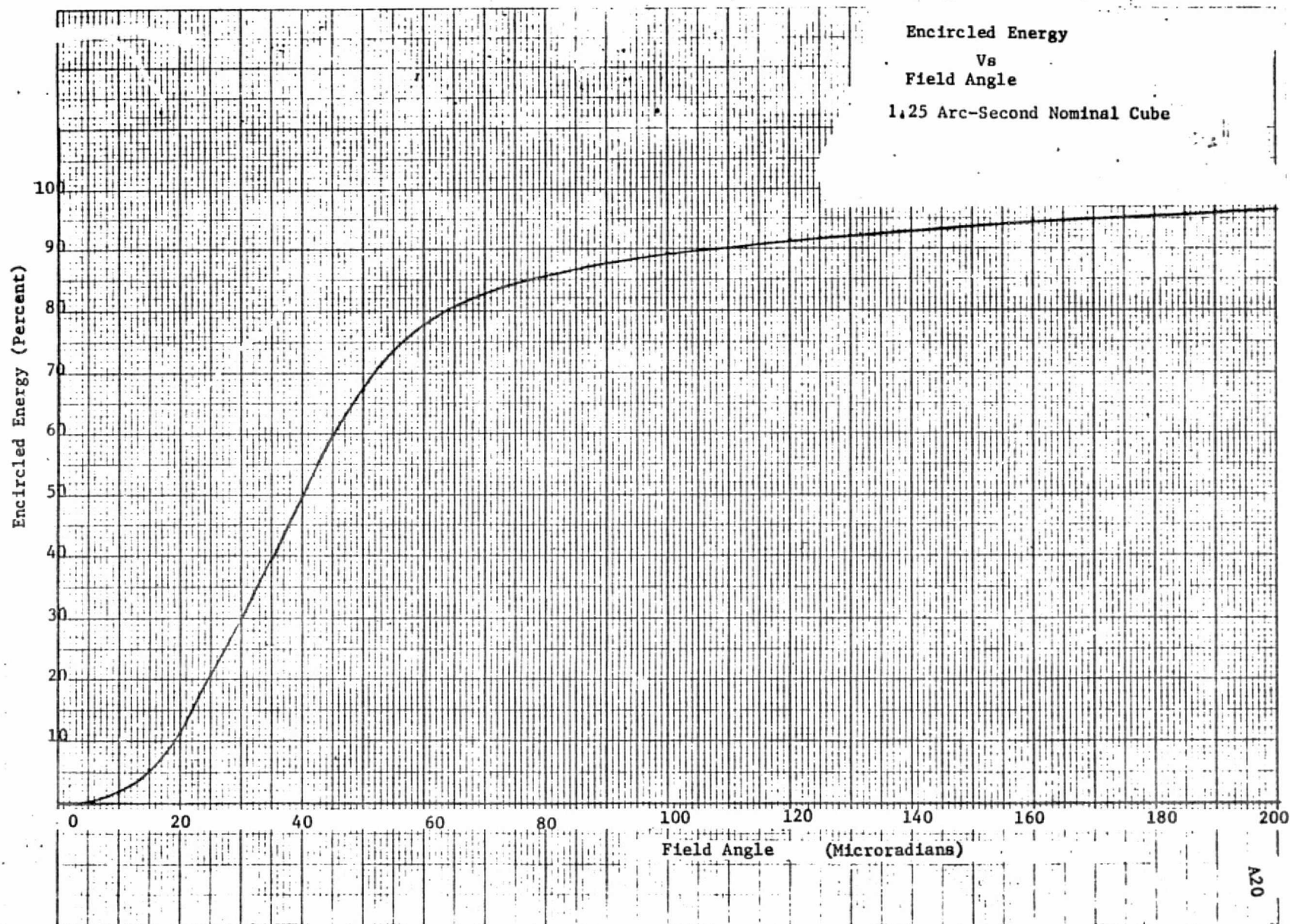
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Figure A16

Encircled Energy
Vs
Field Angle
1.25 Arc-Second Nominal Cube



A20

A21

ENCIRCLED ENERGY

[illegible]

CIRCLE	RADIUS	PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES									
(MI-CRONS)	CENTER (MICRONS):										
	X=	-10.13	10.13	0.0	-10.13	0.0	10.13	0.0	-10.13	10.13	
	Y=	-10.13	-10.13	-10.13	0.0	0.0	0.0	10.13	10.13	10.13	

2.00	0.0	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.0	0.0	
4.00	0.4	0.4	0.4	0.1	0.2	0.1	0.4	0.7	0.7	0.7	
6.00	0.4	0.4	1.4	0.4	1.7	0.4	1.5	0.7	0.7	0.7	
8.00	1.5	1.5	2.5	1.0	1.7	1.0	2.8	2.3	2.2	2.2	
10.00	2.1	2.1	3.4	1.4	3.2	1.4	3.9	3.1	3.1	3.1	
12.00	4.9	4.9	5.3	2.7	3.6	2.7	6.1	6.3	6.2	6.2	
14.00	4.9	4.9	6.8	4.8	5.2	4.8	8.5	6.3	6.2	6.2	
16.00	8.4	8.4	8.9	6.4	6.3	6.4	10.9	10.0	10.0	10.0	
18.00	10.0	10.0	10.5	9.0	10.6	9.0	13.0	11.7	11.7	11.7	
20.00	12.9	12.9	13.7	11.4	10.6	11.4	16.3	14.8	14.8	14.8	
22.00	14.4	14.4	15.8	15.2	16.6	15.2	18.6	16.5	16.5	16.5	
24.00	18.0	18.0	18.4	16.9	19.2	16.9	21.1	20.2	20.2	20.2	
26.00	19.7	19.7	21.3	21.5	25.2	21.5	23.7	22.3	22.2	22.2	
28.00	24.0	24.0	25.9	25.9	26.8	25.9	28.4	26.5	26.5	26.5	
30.00	26.9	26.9	28.7	30.1	32.4	30.1	30.7	29.8	29.8	29.8	
32.00	32.7	32.7	33.1	33.4	35.0	33.3	35.3	35.4	35.4	35.4	
34.00	33.9	33.9	36.5	38.5	38.8	38.5	38.8	36.7	36.6	36.6	
36.00	39.9	39.9	41.0	42.0	42.8	42.0	43.7	42.3	42.3	42.3	
38.00	42.6	42.6	44.3	46.2	47.8	46.2	46.8	45.1	45.1	45.1	
40.00	47.2	47.2	48.3	49.7	50.4	49.7	51.2	49.5	49.5	49.5	
42.00	47.6	49.1	52.0	54.4	56.2	54.4	54.6	51.0	51.3	51.3	
44.00	54.0	54.1	54.9	56.5	59.4	56.5	57.8	56.0	56.0	56.0	
46.00	56.8	56.8	58.4	61.1	64.7	61.1	60.9	58.8	58.8	58.8	
48.00	60.3	60.3	62.2	64.3	66.0	64.3	64.3	62.2	62.2	62.2	
50.00	63.1	63.1	64.6	67.0	70.2	67.0	66.2	64.8	64.8	64.8	
52.00	66.3	66.3	68.0	69.8	71.9	69.8	69.2	67.6	67.6	67.6	
54.00	68.1	68.1	70.6	72.3	74.4	72.3	71.1	69.3	69.3	69.3	
56.00	71.4	71.4	73.8	74.8	75.8	74.8	73.8	72.0	72.0	72.0	
58.00	73.5	73.5	75.3	76.1	77.7	76.1	75.3	73.8	73.8	73.8	
60.00	75.5	75.5	77.4	77.8	79.0	77.8	77.1	75.6	75.6	75.6	
62.00	77.0	77.0	78.8	78.9	80.2	78.9	78.4	76.9	76.9	76.9	
64.00	78.9	78.9	79.8	79.8	81.2	79.8	79.7	78.6	78.6	78.6	
66.00	79.9	79.9	81.0	80.8	82.1	80.8	80.9	79.7	79.7	79.7	
68.00	81.1	81.1	81.9	81.6	82.5	81.6	81.6	81.0	81.0	81.0	
70.00	81.8	81.8	82.6	82.3	83.1	82.3	82.7	81.7	81.7	81.7	
72.00	82.7	82.7	83.2	83.0	83.5	83.0	83.3	82.8	82.8	82.8	
74.00	83.2	83.2	83.9	83.6	84.0	83.6	84.0	83.3	83.3	83.3	
76.00	84.0	84.0	84.4	84.2	84.3	84.2	84.5	84.1	84.1	84.1	
78.00	84.5	84.5	84.7	84.7	84.8	84.7	84.8	84.6	84.6	84.6	
80.00	85.0	85.0	85.1	85.2	85.2	85.2	85.3	85.2	85.2	85.2	

ENCIRCLED ENERGY

1.25 Arc-Second Nominal Cube

CIRCLE #
----- # PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES
RADIUS #
----- #

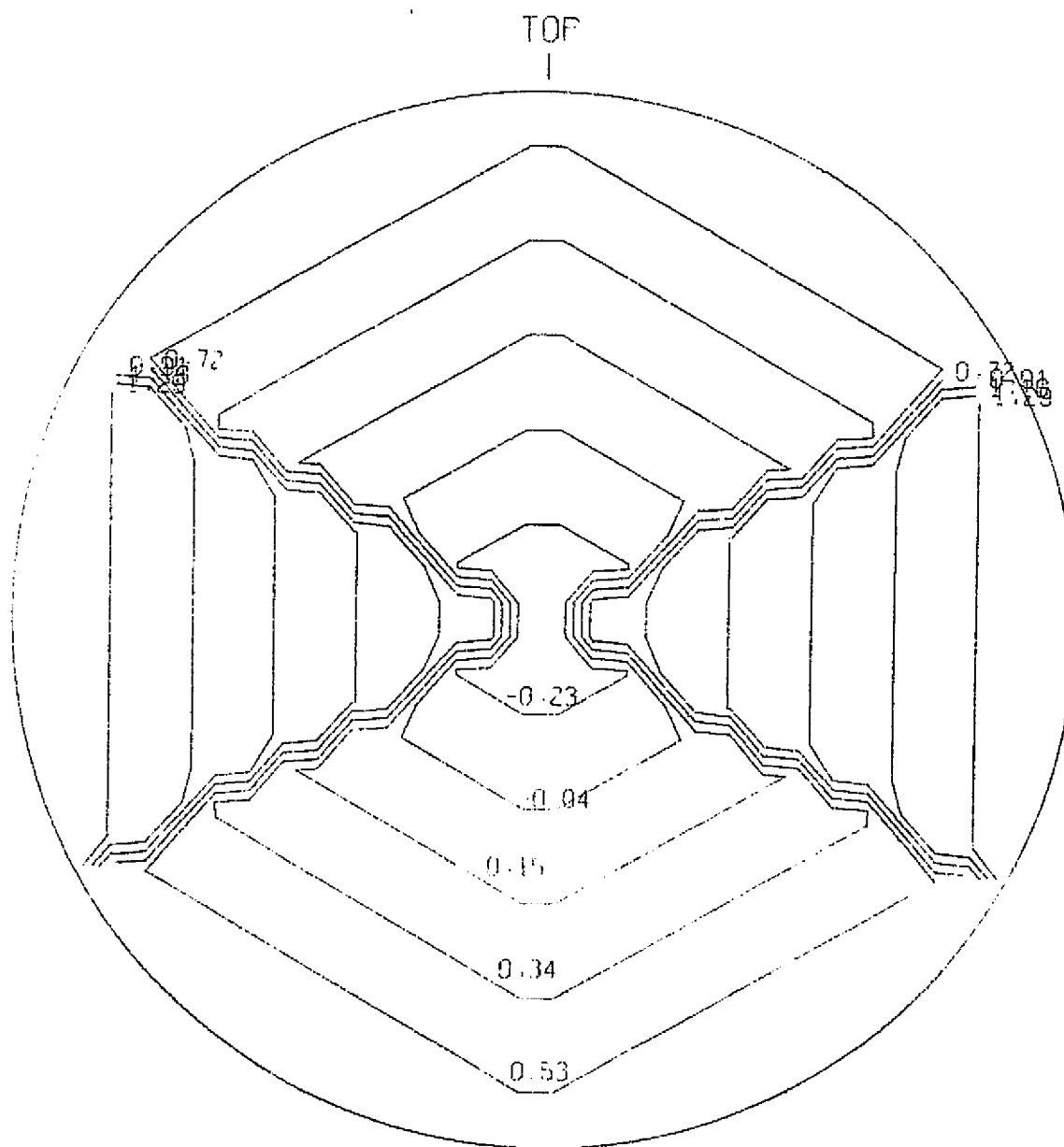
(MI- # CENTER (MICRONS):
CRONS) # X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13
Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13
#

5.00	#	0.4	0.4	1.1	0.3	1.1	0.3	1.2	0.7	0.7
10.00	#	2.1	2.1	3.4	1.4	3.2	1.4	3.9	3.1	3.1
15.00	#	7.3	7.0	8.5	5.6	6.3	5.6	10.2	8.5	8.4
20.00	#	12.9	12.9	13.7	11.4	10.6	11.4	16.3	14.8	14.8
25.00	#	19.2	19.1	20.4	21.0	21.9	21.0	23.0	21.6	21.6
30.00	#	26.9	26.9	28.7	30.1	32.4	30.1	30.7	29.8	29.8
35.00	#	37.6	37.6	38.9	39.5	41.7	39.5	41.1	39.9	39.9
40.00	#	47.2	47.2	48.3	49.7	50.4	49.7	51.2	49.5	49.5
45.00	#	55.6	55.5	56.9	59.6	62.4	59.6	59.5	57.6	57.5
50.00	#	63.1	63.1	64.6	67.0	70.2	67.0	66.2	64.8	64.8
55.00	#	70.2	70.2	72.4	73.6	75.5	73.6	72.8	70.9	70.9
60.00	#	75.5	75.5	77.4	77.8	79.0	77.8	77.1	75.6	75.6
65.00	#	79.3	79.3	80.6	80.4	81.8	80.4	80.4	79.2	79.2
70.00	#	81.8	81.8	82.6	82.3	83.1	82.3	82.7	81.7	81.7
75.00	#	83.6	83.6	84.1	84.0	84.1	84.0	84.3	83.8	83.8
80.00	#	85.0	85.0	85.1	85.2	85.2	85.2	85.3	85.2	85.2
85.00	#	86.0	86.0	86.1	86.4	86.4	86.4	86.3	86.2	86.2
90.00	#	87.0	87.0	87.2	87.4	87.4	87.4	87.3	87.1	87.1
95.00	#	88.0	88.0	88.1	88.2	88.4	88.2	88.2	88.1	88.1
100.00	#	88.8	88.8	89.0	89.0	89.2	89.0	89.0	88.8	88.8
105.00	#	89.5	89.5	89.7	89.6	89.8	89.6	89.7	89.5	89.5
110.00	#	90.1	90.2	90.3	90.2	90.3	90.2	90.3	90.2	90.2
115.00	#	90.7	90.7	90.7	90.7	90.8	90.7	90.7	90.8	90.8
120.00	#	91.2	91.2	91.1	91.3	91.2	91.3	91.2	91.3	91.3
125.00	#	91.6	91.6	91.6	91.7	91.7	91.7	91.7	91.7	91.7
130.00	#	92.0	92.0	92.1	92.1	92.2	92.1	92.2	92.1	92.1
135.00	#	92.5	92.5	92.5	92.5	92.6	92.5	92.5	92.5	92.5
140.00	#	92.9	92.9	92.9	92.9	92.9	92.9	93.0	92.9	92.9
145.00	#	93.2	93.2	93.2	93.2	93.2	93.2	93.2	93.2	93.2
150.00	#	93.5	93.5	93.5	93.5	93.6	93.5	93.5	93.5	93.5
155.00	#	93.9	93.9	93.8	93.9	93.9	93.9	93.8	93.8	93.8
160.00	#	94.2	94.2	94.2	94.2	94.1	94.2	94.1	94.2	94.2
165.00	#	94.5	94.5	94.5	94.5	94.5	94.5	94.5	94.5	94.5
170.00	#	94.7	94.7	94.8	94.8	94.9	94.8	94.8	94.8	94.8
175.00	#	95.0	95.0	95.1	95.1	95.1	95.1	95.1	95.0	95.0
180.00	#	95.3	95.3	95.3	95.3	95.4	95.3	95.3	95.3	95.3
184.99	#	95.5	95.5	95.5	95.6	95.5	95.6	95.5	95.6	95.6
189.99	#	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8
194.99	#	96.0	96.0	96.0	96.0	96.1	96.0	96.0	96.0	96.0
199.99	#	96.3	96.3	96.2	96.3	96.3	96.3	96.2	96.3	96.3

Figure A18

Wavefront Plot - Q Polarization

1.75 Arc Second Nominal Cube

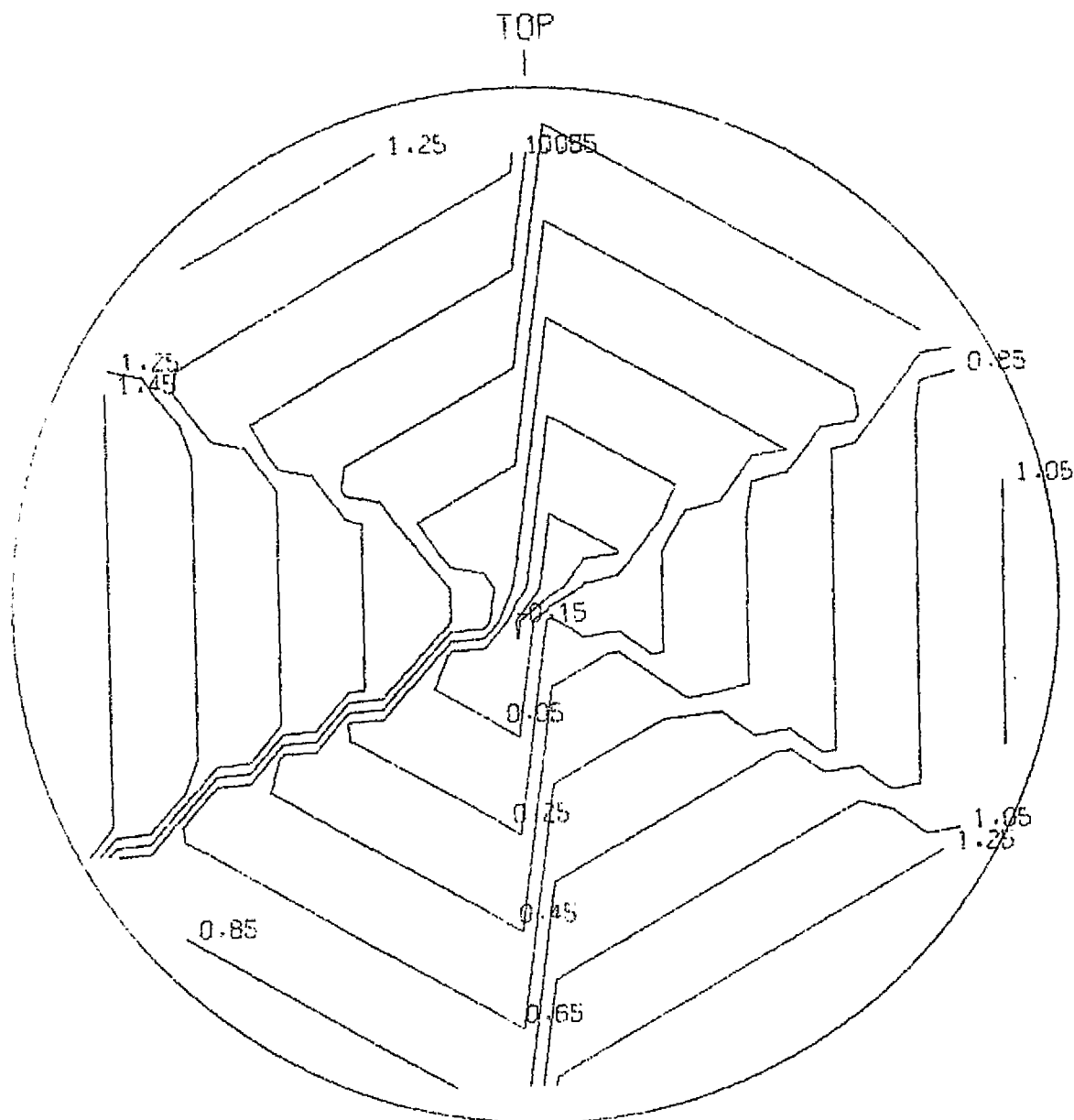


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MAP IN UNITS OF 0.01 WAVES

[illegible]

Figure A20
Wavefront Plot - P Polarization
1.75 Arc Second Nominal Cube



SPREADSHEET MAP OF PRINT SPREAD FUNCTION

11.75 Arc Second Nominal Cube

ONE SPACE REPRESENTS 8.04 MICRONS)

NORMALIZED SO LARGEST VALUE = 0.0234 = 100

TOTAL ENERGY = 0.2461000D+01

MAP REPRESENTS 0.2312441D+01 OR 93.9635 PERCENT OF TOTAL ENERGY

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OF POOR QUALITY

Figure A22

Point Spread Function
1.75 Arc Second Nominal Cube

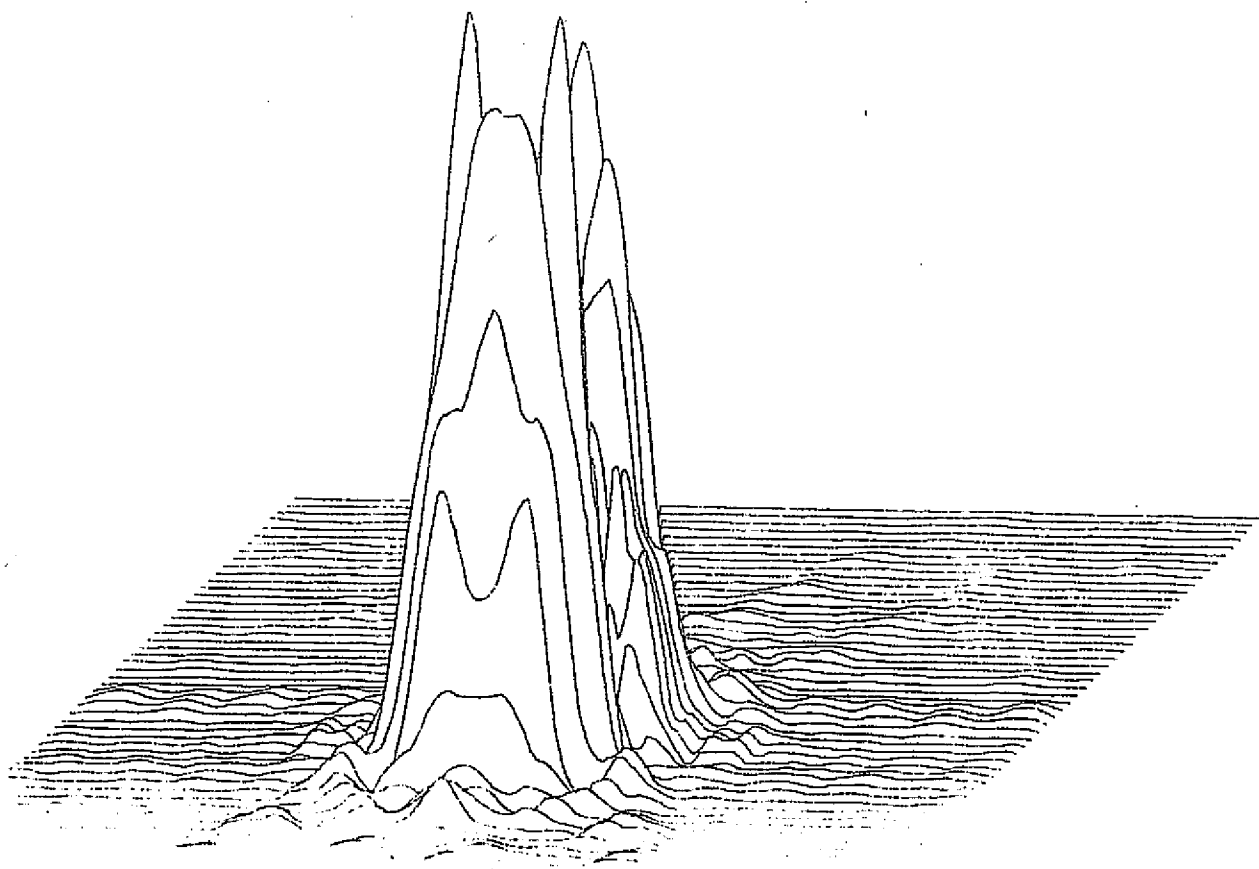


Figure A23

Intensity Distribution - Central 129 Microradians

1.75 Arc Second Nominal Cube

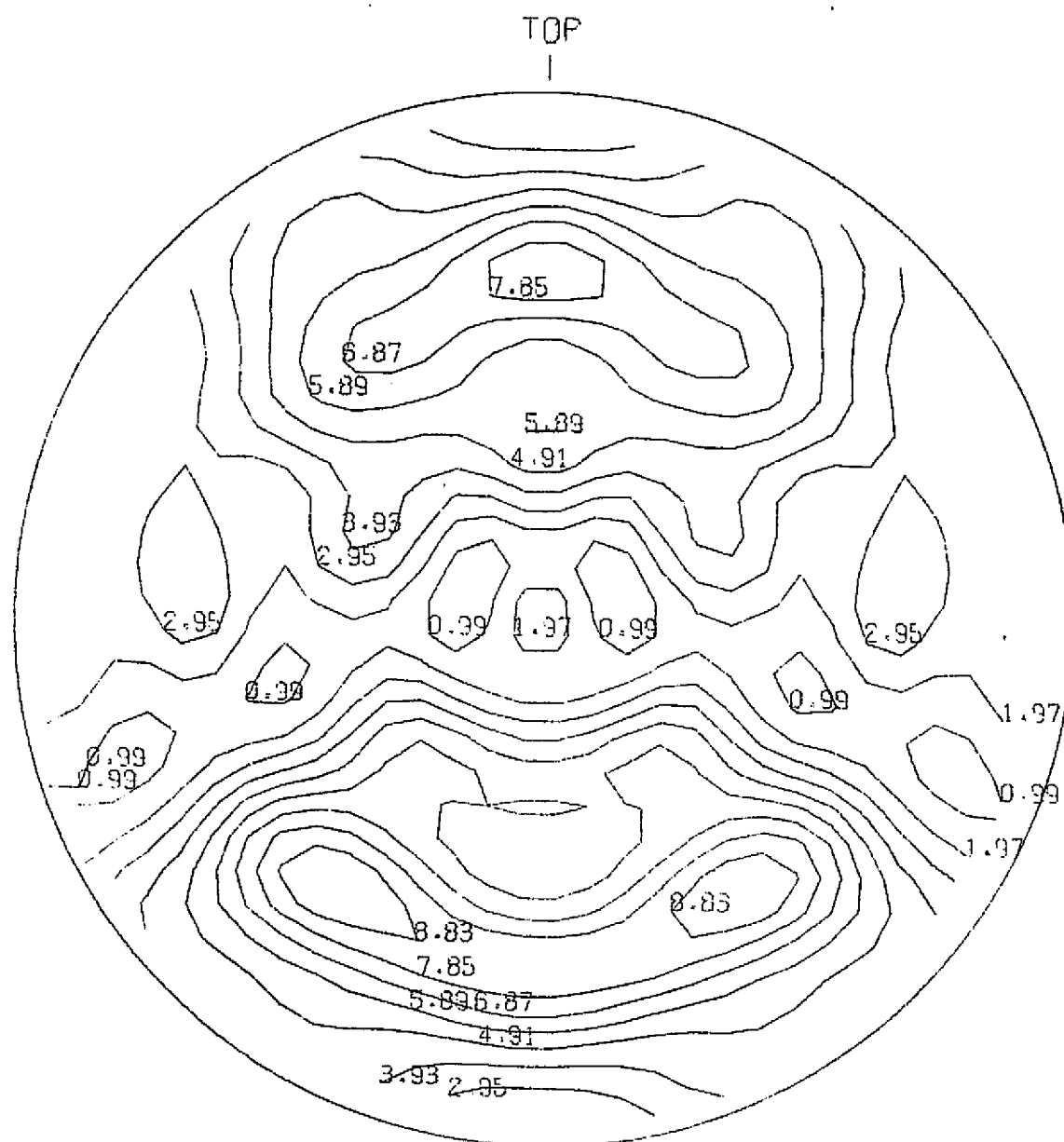
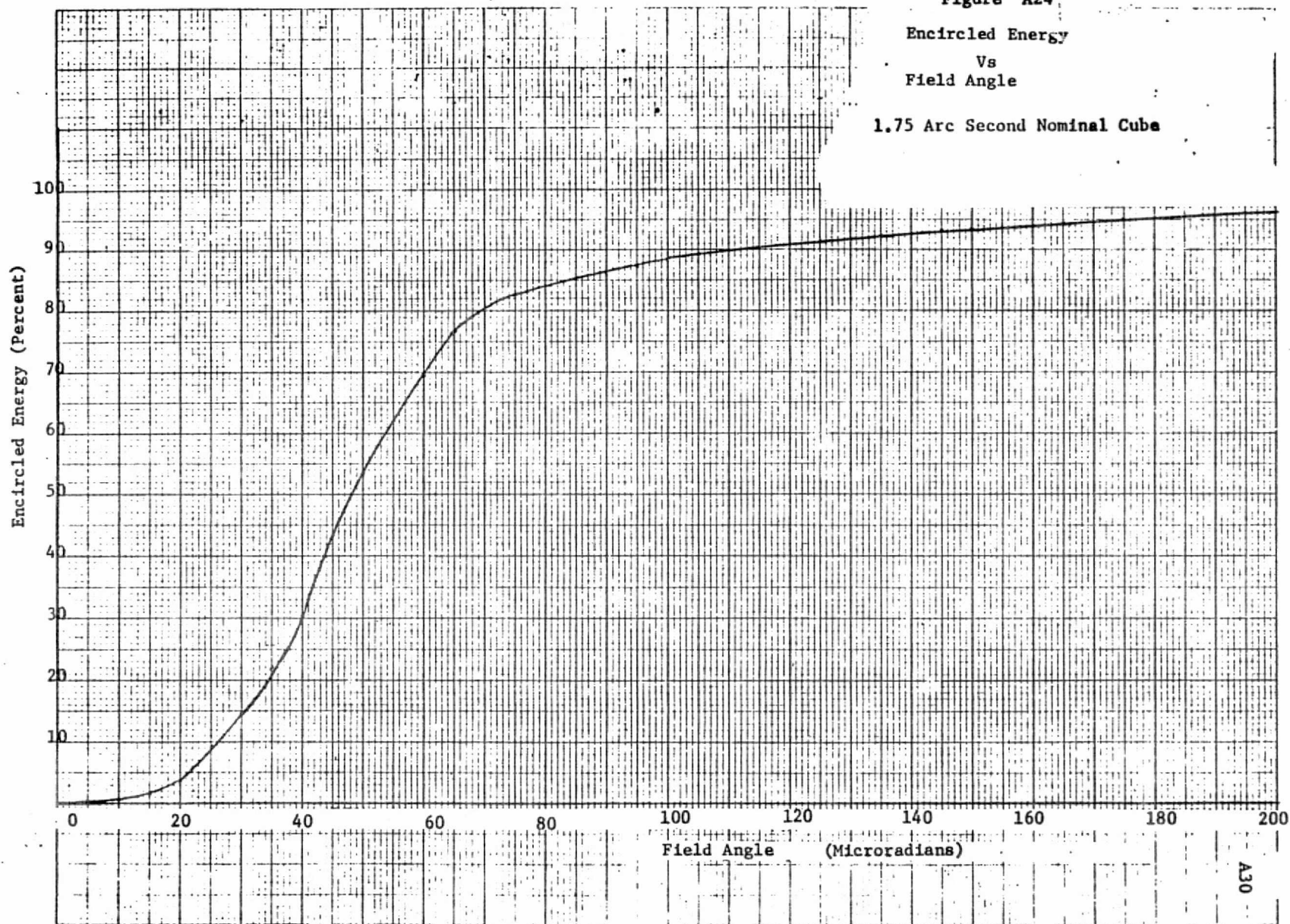


Figure A24
Encircled Energy
Vs
Field Angle
1.75 Arc Second Nominal Cube



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OF POOR QUALITY

Table A6

A31

ENCIRCLED ENERGY

1.75 Arc Second Nominal Cube

CIRCLE *
 ----- * PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES
 RADIUS *
 ----- *

(MI- CENTER (MICRONS):

CPONS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13

*

2.00	*	0.0	0.0	0.1	0.0	0.1	3.0	0.1	0.0	0.0
4.00	*	0.2	0.2	0.1	0.0	0.1	0.0	0.1	0.3	0.3
6.00	*	0.2	0.2	0.4	0.1	0.4	0.1	0.4	0.3	0.3
8.00	*	0.6	0.6	0.7	0.3	0.4	0.3	0.8	0.9	0.9
10.00	*	0.9	0.9	0.9	0.5	0.6	0.5	1.2	1.3	1.3
12.00	*	2.1	2.1	1.5	1.0	0.8	1.0	1.9	2.5	2.5
14.00	*	2.1	2.1	2.2	1.9	1.3	1.9	2.9	2.5	2.5
16.00	*	3.6	3.6	3.0	2.5	1.7	2.5	3.8	4.1	4.1
18.00	*	4.3	4.3	3.9	3.6	3.7	3.6	4.8	4.9	4.9
20.00	*	5.8	5.8	5.4	4.6	3.7	4.6	6.2	6.4	6.4
22.00	*	6.5	6.5	6.9	6.3	6.6	6.3	7.7	7.2	7.2
24.00	*	8.6	8.6	8.3	7.1	8.0	7.1	9.0	9.4	9.4
26.00	*	9.6	9.6	10.3	9.3	10.9	9.3	10.9	10.7	10.7
28.00	*	12.6	12.6	13.5	11.9	11.7	11.9	14.3	13.8	13.8
30.00	*	14.6	14.6	15.4	14.4	14.8	14.4	16.2	16.1	16.1
32.00	*	18.8	18.8	18.5	16.7	16.7	16.6	19.5	20.3	20.3
34.00	*	19.8	19.8	21.1	20.5	19.4	20.5	22.6	21.3	21.3
36.00	*	24.4	24.4	24.4	23.2	23.0	23.2	26.4	25.9	25.9
38.00	*	26.7	26.7	27.1	27.0	27.8	27.0	29.2	28.5	28.5
40.00	*	30.6	30.6	30.5	30.2	30.4	30.2	33.1	32.5	32.5
42.00	*	32.6	32.6	34.3	35.1	36.6	35.1	36.8	34.6	34.6
44.00	*	37.0	36.9	37.1	37.4	40.0	37.4	39.8	39.0	39.0
46.00	*	40.0	40.0	41.1	43.0	46.1	43.0	43.5	42.2	42.2
48.00	*	44.0	44.0	45.7	47.1	47.7	47.1	47.9	46.2	46.2
50.00	*	47.5	47.5	48.6	50.8	53.1	50.8	50.5	49.7	49.6
52.00	*	51.7	51.7	52.9	54.7	55.8	54.7	54.5	53.6	53.6
54.00	*	54.1	54.1	56.3	58.5	60.0	58.5	57.6	55.9	55.9
56.00	*	58.5	58.5	60.7	62.4	62.8	62.3	61.8	59.8	59.8
58.00	*	61.6	61.6	63.2	64.8	66.8	64.8	64.3	62.7	62.7
60.00	*	64.6	64.6	66.6	67.9	69.7	67.9	67.5	65.5	65.5
62.00	*	66.9	66.9	69.2	70.6	72.7	70.6	70.0	67.6	67.6
64.00	*	70.2	70.2	71.3	72.5	75.1	72.5	72.2	70.7	70.7
66.00	*	72.1	72.1	74.0	75.0	77.5	75.0	74.7	72.6	72.6
68.00	*	74.5	74.5	76.0	75.7	78.6	76.7	76.4	75.0	75.0
70.00	*	76.0	76.0	77.9	78.3	80.2	78.3	78.1	76.4	76.4
72.00	*	78.1	78.1	79.4	79.7	81.3	79.7	79.4	78.3	78.3
74.00	*	79.2	79.2	81.0	80.9	82.2	80.9	80.8	79.3	79.3
76.00	*	80.8	80.8	82.1	82.0	82.8	82.0	81.8	80.9	80.9
78.00	*	81.9	81.9	82.8	82.6	83.4	82.6	82.5	81.8	81.8
80.00	*	82.9	82.9	83.6	83.4	83.9	83.4	83.4	82.8	82.8

*

Table A7

432

ENCIRCLED ENERGY

1.75 Arc Second Nominal Cube

CIRCLE *
 ----- * PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES
 RADIUS *
 ----- *

(MI- * CENTER (MICRONS):

CRONS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13

*

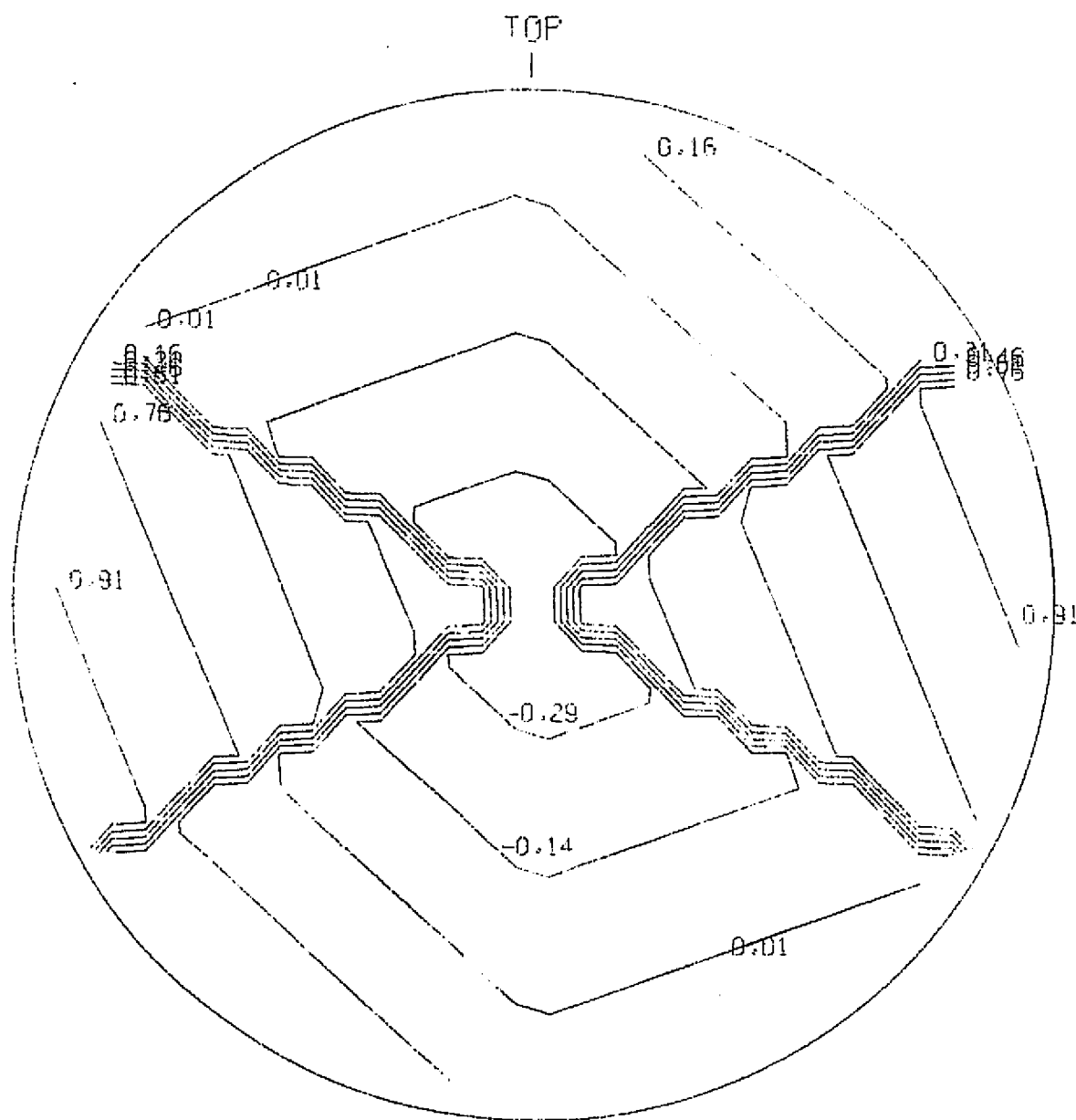
5.00	*	0.2	0.2	0.3	0.1	0.3	0.1	0.3	0.3	0.3
10.00	*	0.9	0.9	0.9	0.5	0.6	0.5	1.2	1.3	1.3
15.00	*	3.7	3.0	2.7	2.2	1.7	2.2	3.4	3.4	3.4
20.00	*	5.8	5.8	5.4	4.6	3.7	4.6	6.2	6.4	6.4
25.00	*	9.3	9.3	9.8	9.1	9.1	9.1	10.4	10.3	10.3
30.00	*	14.6	14.6	15.4	14.4	14.8	14.4	16.2	16.1	16.1
35.00	*	22.5	22.5	22.6	21.2	22.0	21.2	24.2	23.9	23.9
40.00	*	30.6	30.6	30.5	30.2	30.4	30.2	33.1	32.5	32.5
45.00	*	38.6	38.6	39.3	41.1	43.5	41.1	41.8	40.7	40.7
50.00	*	47.5	47.5	48.6	50.8	53.1	50.8	50.5	49.7	49.6
55.00	*	57.0	57.0	58.7	60.4	62.1	60.4	60.0	58.4	58.4
60.00	*	64.6	64.6	66.6	67.9	69.7	67.9	67.5	65.5	65.5
65.00	*	71.1	71.1	73.0	74.1	76.6	74.1	73.7	71.6	71.6
70.00	*	76.0	76.0	77.9	78.3	80.2	78.3	78.1	76.4	76.4
75.00	*	81.2	80.2	81.5	81.5	82.5	81.5	81.4	80.2	80.2
80.00	*	82.9	82.9	83.6	83.4	83.9	83.4	83.4	82.8	82.8
85.00	*	84.5	84.5	84.9	84.8	85.1	84.8	85.0	84.5	84.5
90.00	*	85.8	85.8	86.0	86.0	86.1	86.0	86.2	85.9	85.9
95.00	*	86.9	86.9	86.9	87.1	87.2	87.1	87.2	87.1	87.1
100.00	*	87.9	87.9	87.9	88.1	88.3	88.1	88.0	88.0	88.0
105.00	*	88.7	88.7	88.9	89.0	89.2	89.0	88.9	88.7	88.7
110.00	*	89.5	89.5	89.7	89.7	89.9	89.7	89.6	89.5	89.5
115.00	*	90.2	90.2	90.3	90.2	90.4	90.2	90.3	90.2	90.2
120.00	*	90.8	90.8	90.9	90.8	90.9	90.8	90.9	90.8	90.8
125.00	*	91.2	91.2	91.3	91.3	91.3	91.3	91.5	91.3	91.3
130.00	*	91.7	91.7	91.7	91.8	91.8	91.8	91.9	91.8	91.8
135.00	*	92.2	92.2	92.2	92.2	92.3	92.2	92.2	92.2	92.2
140.00	*	92.6	92.6	92.6	92.7	92.7	92.7	92.7	92.6	92.6
145.00	*	93.0	93.0	93.0	93.1	93.1	93.1	93.1	93.0	93.0
150.00	*	93.3	93.3	93.4	93.4	93.5	93.4	93.4	93.4	93.4
155.00	*	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7
160.00	*	94.1	94.1	94.1	94.0	94.0	94.0	94.0	94.0	94.0
165.00	*	94.4	94.4	94.4	94.3	94.3	94.3	94.3	94.3	94.3
170.00	*	94.6	94.6	94.7	94.7	94.7	94.7	94.7	94.6	94.6
175.00	*	94.9	94.9	94.9	94.9	95.0	94.9	95.0	94.9	94.9
180.00	*	95.2	95.2	95.2	95.2	95.3	95.2	95.3	95.2	95.2
184.99	*	95.5	95.5	95.4	95.5	95.5	95.5	95.5	95.5	95.5
189.99	*	95.7	95.7	95.7	95.8	95.7	95.8	95.7	95.7	95.7
194.99	*	95.9	95.9	95.9	95.0	96.0	96.0	95.9	96.0	96.0
199.99	*	96.2	96.2	96.2	96.2	96.2	96.2	96.1	96.2	96.2

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MAP IN UNITS OF 0.01 WAVES

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Figure A26
Wavefront Plot - Q Polarization
0.9 Arc-Second Off-Nominal Cube

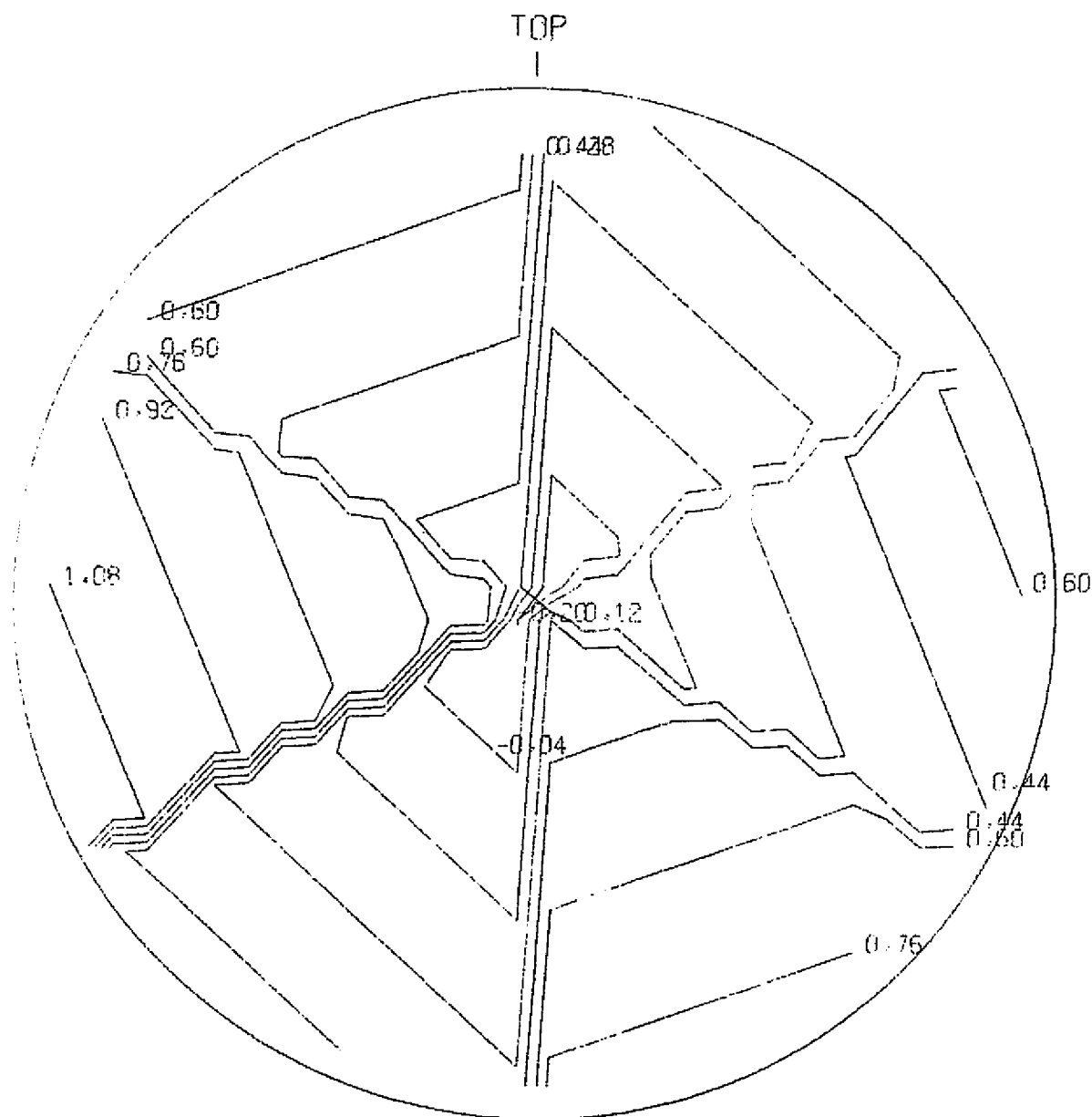


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MAP IN UNITS OF 0.01 WAVES

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OF POOR QUALITY

Figure A28
0.9 Arc-Second Off-Nominal Cube
Wavefront Plot - P Polarization



ORIGINAL PAGE IS
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Figure A29

PRINTER MAP OF POINT SPREAD FUNCTION

0.9 Arc-Second Off-Nominal Cube

(ONE SPACE REPRESENTS 8.04 MICRONS)

NORMALIZED SD LARGST VALUE = 0.0510 = 100

TOTAL ENERGY = 0.2461000D+01

MAP REPRESENTS 0.23157870+01 OR 94.0995 PERCENT OF TOTAL ENERGY

[illegible]

Figure A30

Point Spread Function
0.9 Arc-Second Off-Nominal Cube.

ORIGINAL PAGE IS
OF POOR QUALITY

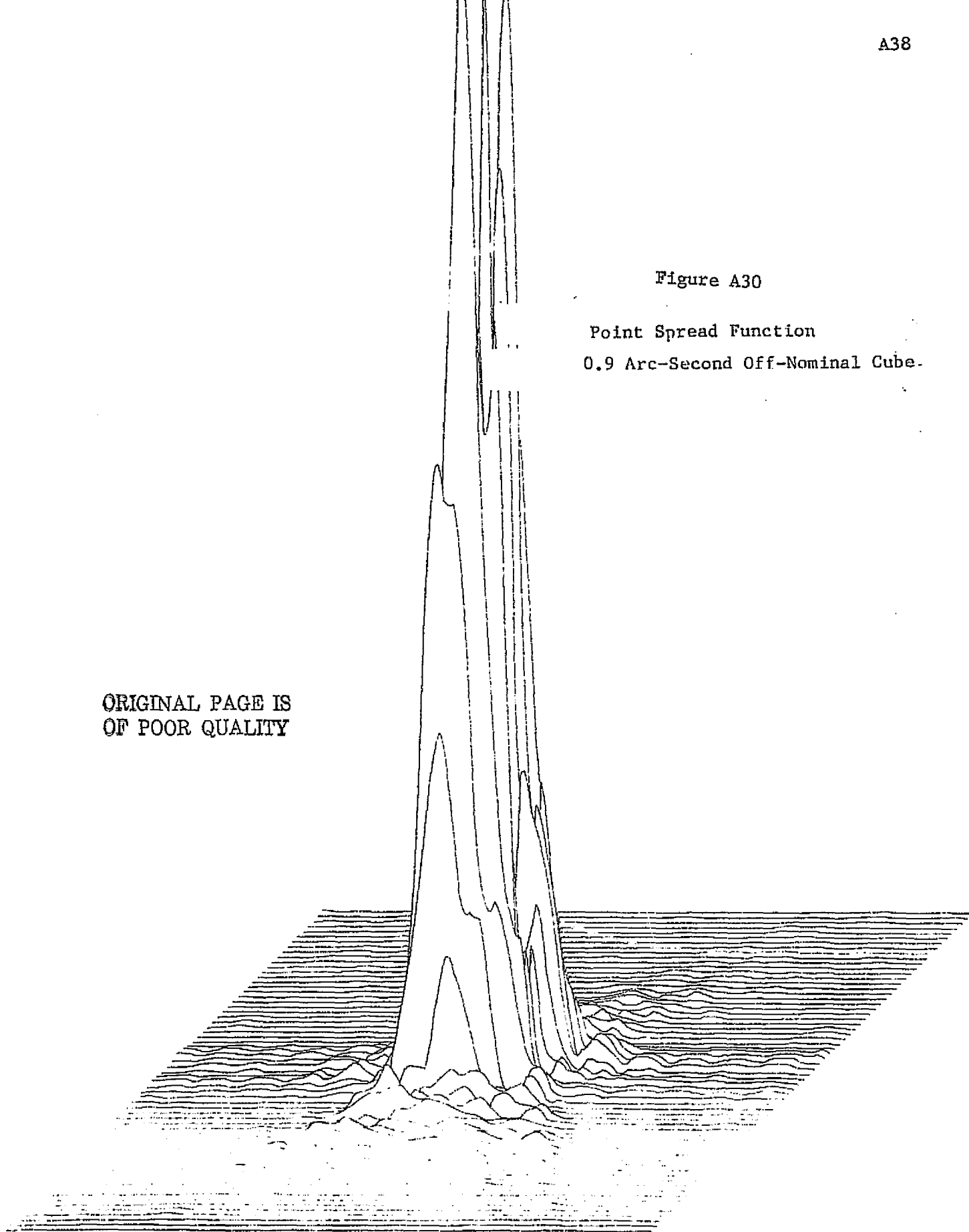


Figure A31

Intensity Distribution - Central 129 Microradians
0.9 Arc-Second Off-Nominal Cube

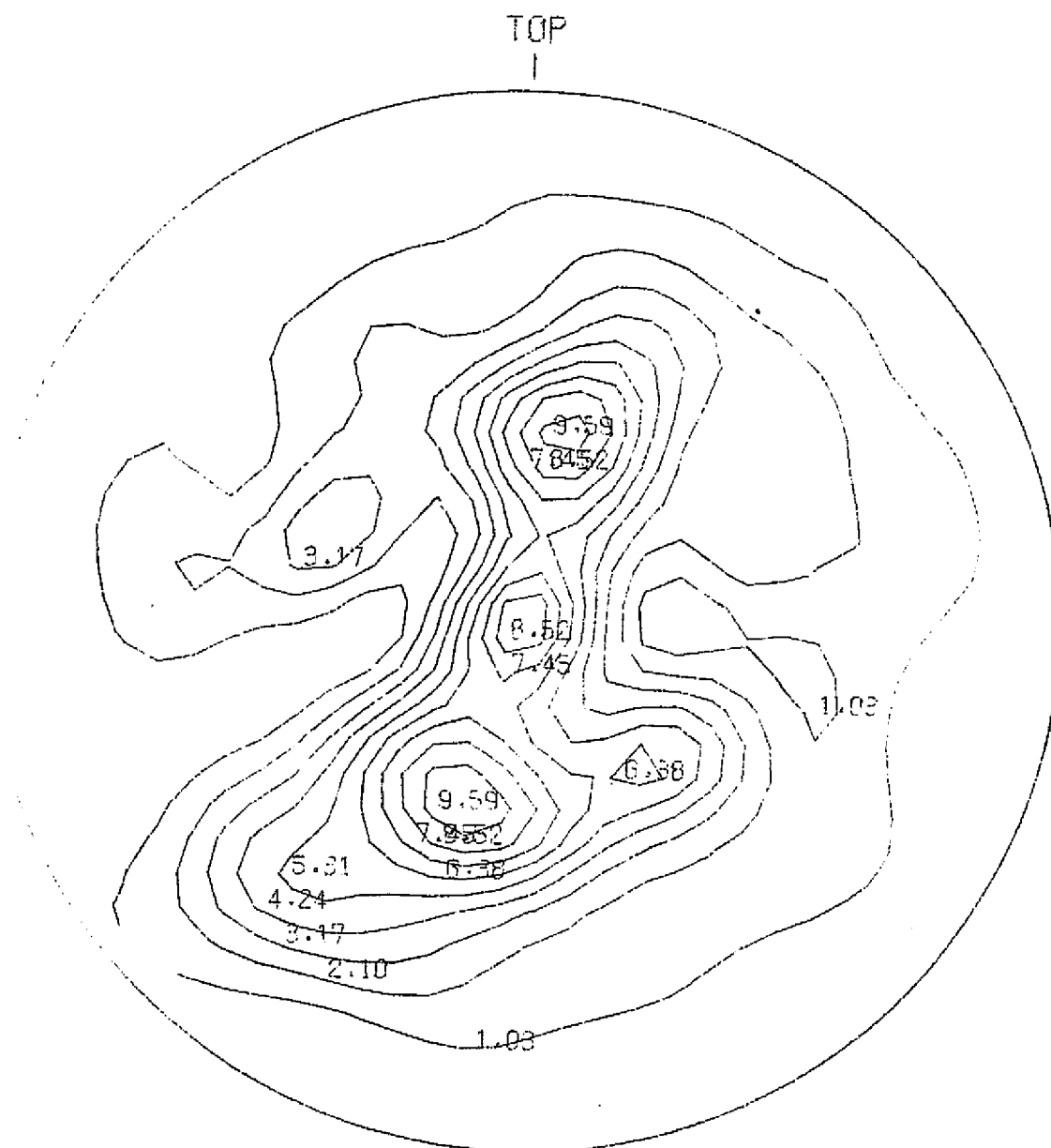
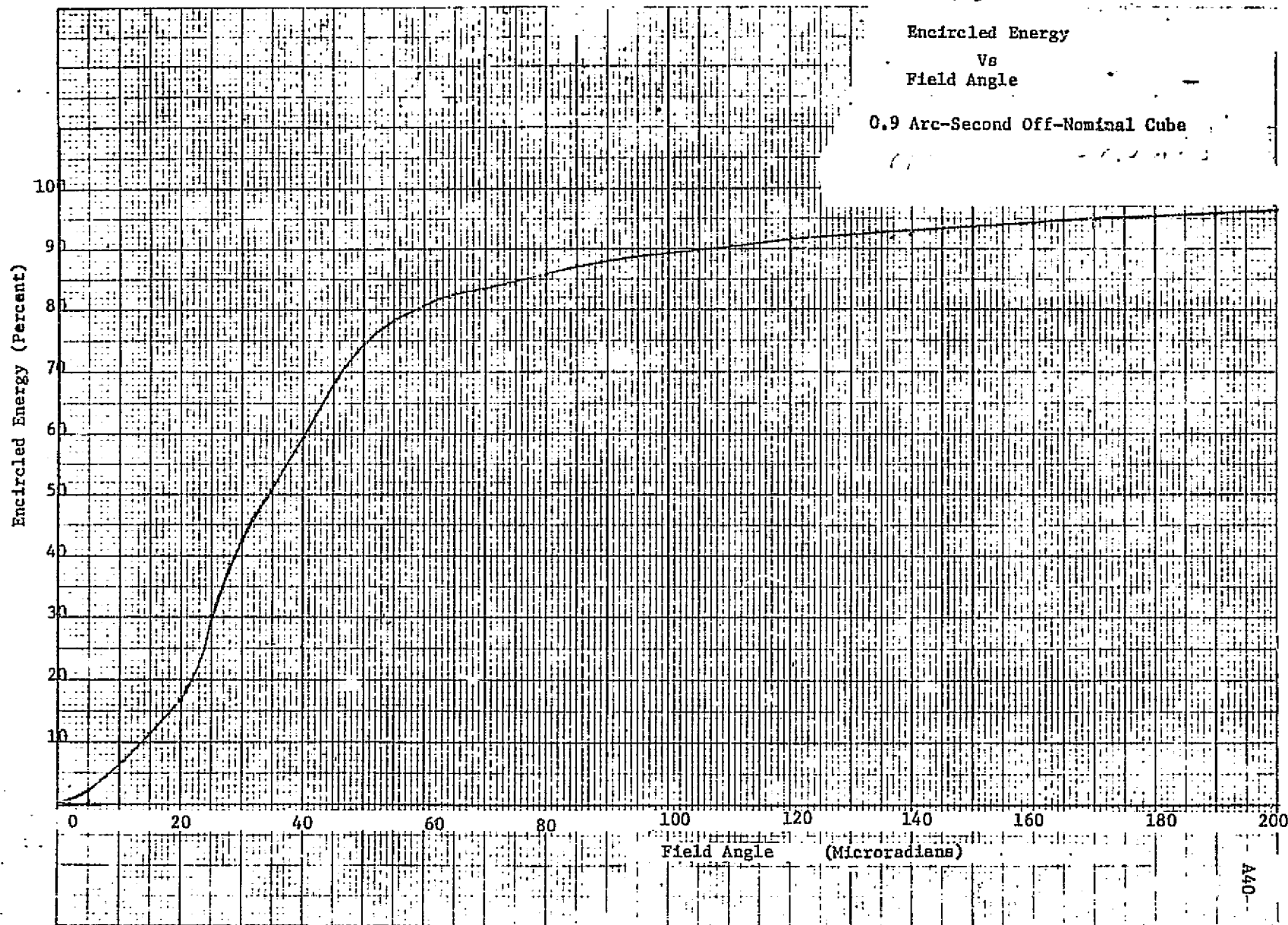


Figure A32

Encircled Energy
Vs
Field Angle

0.9 Arc-Second Off-Nominal Cube



ORIGINAL PAGE IS
OF POOR QUALITY

ENCIRCLED ENERGY

0.9 Arc-Second Off-Nominal Cube

CIRCLE *
 ----- * PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES
 RADIUS *
 ----- *

(MI- * CENTER (MICRONS):
 CRONS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13
 * Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13
 *

2.00	*	0.0	0.0	0.3	0.1	0.5	0.1	0.3	0.0	0.0
4.00	*	0.4	0.9	0.7	0.3	0.5	0.3	0.7	1.3	0.9
6.00	*	0.4	0.9	2.1	0.9	3.7	1.0	2.4	1.3	0.9
8.00	*	1.6	2.8	4.0	2.2	3.7	2.2	4.3	3.7	2.8
10.00	*	2.4	3.8	5.2	2.9	6.9	2.9	5.9	5.0	3.9
12.00	*	6.1	8.0	8.3	5.2	7.7	5.3	9.4	9.6	8.3
14.00	*	6.1	8.0	10.5	8.1	10.1	8.3	12.8	9.6	8.3
16.00	*	11.0	12.9	13.7	10.4	11.7	10.7	16.3	14.9	13.6
18.00	*	13.1	14.9	15.8	13.7	16.9	14.1	19.2	17.3	15.9
20.00	*	17.1	18.6	20.0	17.3	16.9	17.7	23.6	21.2	20.0
22.00	*	19.2	20.7	22.4	21.8	24.0	22.4	26.3	23.5	22.2
24.00	*	23.7	25.2	25.3	24.1	27.1	24.6	29.2	28.2	26.8
26.00	*	25.7	27.3	28.4	29.5	34.1	30.0	32.0	30.7	29.0
28.00	*	30.1	32.1	33.1	34.5	35.9	34.9	36.8	35.4	33.4
30.00	*	33.3	35.4	36.2	39.2	42.4	39.5	39.2	39.1	36.8
32.00	*	39.2	41.4	40.6	42.8	45.1	42.8	43.6	44.6	42.3
34.00	*	40.3	42.6	44.3	48.1	49.2	48.0	47.0	45.8	43.5
36.00	*	46.6	48.5	49.0	51.6	53.0	51.4	51.7	51.1	49.2
38.00	*	49.3	51.2	52.5	55.4	57.2	55.1	54.6	53.5	51.9
40.00	*	54.1	55.2	56.4	58.7	59.5	58.4	58.7	57.2	56.4
42.00	*	56.6	57.5	59.9	52.4	64.1	62.1	61.8	59.2	58.6
44.00	*	61.2	61.3	62.5	54.3	66.6	63.9	64.5	62.6	62.7
46.00	*	63.8	63.5	65.5	57.6	70.6	67.3	67.2	64.7	65.3
48.00	*	67.2	66.2	68.5	70.1	71.7	69.9	69.9	67.5	68.4
50.00	*	69.4	68.5	70.5	71.9	74.7	71.7	71.5	69.7	70.6
52.00	*	72.1	70.8	73.0	74.0	75.9	73.9	73.8	71.6	72.8
54.00	*	73.5	72.2	75.1	75.7	77.6	75.7	75.3	73.1	74.1
56.00	*	75.9	74.6	77.3	77.5	78.6	77.5	77.2	75.1	76.1
58.00	*	77.4	76.3	78.5	78.5	79.8	78.5	78.3	76.6	77.4
60.00	*	79.0	77.7	79.9	79.7	80.6	79.7	79.5	77.8	78.7
62.00	*	80.0	78.8	80.8	80.5	81.4	80.5	80.4	78.9	79.7
64.00	*	81.4	80.3	81.5	81.2	82.1	81.2	81.3	80.1	81.0
66.00	*	82.0	81.1	82.2	82.0	82.7	82.0	82.1	81.1	81.7
68.00	*	82.8	82.0	82.8	82.6	83.0	82.6	82.8	82.1	82.7
70.00	*	83.2	82.6	83.4	83.2	83.5	83.2	83.5	82.7	83.2
72.00	*	83.8	83.5	83.8	83.8	84.0	83.7	84.0	83.6	83.9
74.00	*	84.1	83.9	84.4	84.4	84.5	84.3	84.6	84.0	84.3
76.00	*	84.6	84.6	84.8	84.9	84.8	84.8	85.1	84.7	84.8
78.00	*	85.0	85.1	85.1	85.3	85.4	85.3	85.4	85.3	85.2
80.00	*	85.4	85.6	85.6	85.7	85.8	85.7	85.8	85.8	85.6

ORIGINAL PAGE IS
 OF POOR QUALITY

ENCIRCLED ENERGY

0.9 Arc-Second Off-Nominal Cube

CIRCLE *
 RADIUS * PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

(MI- * CENTER (MICRONS):
 CRONS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13
 * Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13
 *

5.00	*	0.4	0.9	1.8	0.9	2.2	1.0	2.0	1.3	0.9
10.00	*	2.4	3.8	5.2	2.9	6.9	2.9	5.9	5.0	3.9
15.00	*	9.7	10.9	13.0	9.4	11.7	9.6	15.3	12.8	11.5
20.00	*	17.1	18.6	20.0	17.3	16.9	17.7	23.6	21.2	20.0
25.00	*	25.0	26.6	27.4	28.9	30.2	29.4	31.4	29.8	28.3
30.00	*	33.3	35.4	36.2	39.2	42.4	39.5	39.2	39.1	36.8
35.00	*	44.4	46.3	46.9	49.0	52.0	49.0	49.2	48.9	46.9
40.00	*	54.1	55.2	56.4	58.7	59.5	58.4	58.7	57.2	56.4
45.00	*	62.7	62.5	64.2	65.5	68.8	66.2	66.0	64.0	64.3
50.00	*	69.4	68.5	70.5	71.9	74.7	71.7	71.5	69.7	70.6
55.00	*	75.1	73.8	76.3	76.7	78.4	76.7	76.4	74.2	75.3
60.00	*	79.7	77.7	79.9	79.7	80.6	79.7	79.5	77.8	78.7
65.00	*	81.7	80.6	82.0	81.7	82.5	81.7	81.8	80.6	81.4
70.00	*	83.2	82.6	83.4	83.2	83.5	83.2	83.5	82.7	83.2
75.00	*	84.4	84.4	84.6	84.6	84.6	84.6	84.8	84.5	84.6
80.00	*	85.4	85.6	85.6	85.7	85.8	85.7	85.8	85.8	85.6
85.00	*	86.4	86.6	86.7	86.9	87.1	86.9	86.8	86.7	86.6
90.00	*	87.4	87.5	87.7	87.8	88.0	87.8	87.7	87.6	87.5
95.00	*	88.5	88.4	88.6	88.5	88.7	88.6	88.5	88.4	88.5
100.00	*	89.3	89.0	89.3	89.2	89.4	89.2	89.3	89.0	89.2
105.00	*	89.8	89.6	89.9	89.8	89.9	89.8	90.0	89.7	89.9
110.00	*	90.3	90.3	90.4	90.4	90.4	90.4	90.5	90.4	90.4
115.00	*	90.8	90.9	90.8	90.9	91.0	90.9	90.9	91.0	90.9
120.00	*	91.2	91.4	91.3	91.4	91.5	91.4	91.4	91.4	91.3
125.00	*	91.7	91.8	91.8	91.9	91.9	91.8	91.8	91.8	91.7
130.00	*	92.2	92.2	92.2	92.2	92.3	92.2	92.2	92.2	92.2
135.00	*	92.5	92.6	92.5	92.5	92.6	92.6	92.6	92.6	92.5
140.00	*	92.9	93.0	93.0	92.9	92.9	93.0	92.9	93.0	92.8
145.00	*	93.2	93.3	93.3	93.3	93.2	93.3	93.2	93.2	93.2
150.00	*	93.6	93.6	93.6	93.6	93.7	93.6	93.5	93.5	93.6
155.00	*	93.9	93.9	93.9	93.9	94.0	93.9	93.9	93.8	93.9
160.00	*	94.3	94.2	94.2	94.3	94.2	94.3	94.2	94.2	94.3
165.00	*	94.5	94.5	94.5	94.6	94.5	94.5	94.6	94.5	94.5
170.00	*	94.8	94.8	94.8	94.8	94.9	94.8	94.8	94.8	94.8
175.00	*	95.0	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.0
180.00	*	95.3	95.4	95.3	95.3	95.4	95.4	95.3	95.3	95.3
184.99	*	95.6	95.6	95.5	95.6	95.5	95.6	95.5	95.6	95.6
189.99	*	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8
194.99	*	96.0	96.0	96.1	96.0	96.1	96.0	96.1	96.0	96.0
199.99	*	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3

ORIGINAL PAGE IS
 OF POOR QUALITY

Table A10

A43

ENCIRCLED ENERGY

***** PERFECT CUBE CORNER *****

CIRCLE *
----- * PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES
RADIUS *
----- *

(MI- * CENTER (MICRONS):
CRONS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13
* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13
*

2.00	*	0.0	0.0	0.4	0.5	1.3	0.5	0.4	0.0	0.0
4.00	*	1.1	1.1	1.1	1.3	1.3	1.3	1.1	1.9	1.9
6.00	*	1.1	1.1	3.1	3.8	9.5	3.8	3.4	1.9	1.9
8.00	*	3.7	3.7	6.4	7.5	9.5	7.5	7.0	5.9	5.9
10.00	*	5.2	5.2	7.9	9.4	17.6	9.4	9.2	8.0	8.0
12.00	*	11.9	11.9	13.5	15.2	19.5	15.2	15.6	16.1	16.1
14.00	*	11.9	11.9	17.3	19.9	24.4	19.9	21.8	16.1	16.1
16.00	*	20.3	20.2	22.5	25.1	27.2	25.1	27.8	25.2	25.2
18.00	*	23.7	23.6	26.1	29.1	34.1	29.1	33.3	29.1	29.1
20.00	*	29.3	29.3	32.3	35.6	34.1	35.5	40.3	34.9	34.9
22.00	*	32.8	32.8	36.4	39.8	42.3	39.8	45.2	38.8	38.8
24.00	*	38.9	38.9	39.8	43.5	46.1	43.5	48.6	44.8	44.8
26.00	*	41.6	41.5	44.9	48.2	54.2	48.2	52.8	47.7	47.7
28.00	*	46.7	46.6	49.8	53.5	56.3	53.5	57.1	52.1	52.1
30.00	*	50.2	50.2	54.4	57.2	63.4	57.2	59.5	55.8	55.7
32.00	*	56.2	56.2	58.3	60.9	66.0	60.9	62.5	60.2	60.2
34.00	*	57.2	57.1	62.9	64.6	69.7	64.6	65.0	61.1	61.1
36.00	*	63.1	63.1	67.1	67.8	72.1	67.8	68.2	65.2	65.2
38.00	*	65.5	65.5	70.2	70.5	74.3	70.5	69.3	66.7	66.7
40.00	*	69.1	69.1	73.4	72.7	75.2	72.7	72.1	69.5	69.5
42.00	*	71.3	71.3	75.3	74.6	76.6	74.6	73.5	71.0	71.0
44.00	*	74.4	74.4	76.5	75.8	77.3	75.8	75.0	73.3	73.3
46.00	*	75.7	75.7	77.4	76.8	78.2	76.8	76.2	74.7	74.7
48.00	*	77.3	77.3	78.3	77.8	78.5	77.8	77.5	76.6	76.6
50.00	*	78.2	78.2	78.6	78.3	79.0	78.3	78.2	77.8	77.8
52.00	*	79.2	79.2	79.1	79.2	79.3	79.2	79.1	78.8	78.8
54.00	*	79.6	79.6	79.7	79.8	79.7	79.8	80.0	79.6	79.6
56.00	*	80.3	80.3	80.2	80.6	80.1	80.6	80.9	80.5	80.5
58.00	*	80.8	80.8	80.7	81.1	80.8	81.1	81.5	81.3	81.3
60.00	*	81.4	81.4	81.2	81.7	81.5	81.7	82.1	81.9	81.9
62.00	*	81.8	81.8	81.9	82.3	82.3	82.3	82.7	82.3	82.3
64.00	*	82.6	82.6	82.3	82.8	83.1	82.8	83.0	83.1	83.1
66.00	*	83.0	83.0	83.2	83.5	84.0	83.5	83.7	83.4	83.4
68.00	*	83.7	83.7	83.7	84.1	84.5	84.1	84.1	84.0	84.0
70.00	*	84.1	84.1	84.6	84.7	85.2	84.7	84.7	84.3	84.3
72.00	*	84.8	84.8	85.1	85.2	85.7	85.2	85.1	84.9	84.9
74.00	*	85.2	85.2	85.9	85.7	86.2	85.7	85.6	85.2	85.2
76.00	*	85.9	85.9	86.3	86.2	86.6	86.2	86.1	85.7	85.7
78.00	*	86.3	86.3	86.8	86.5	87.0	86.5	86.4	86.1	86.1
80.00	*	86.8	86.8	87.1	86.9	87.3	86.9	86.8	86.6	86.6

Table All

ENCIRCLED ENERGY

PERFECT CUBE CORNER

CIRCLE *

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

RADIUS *

(MICRONS) * CENTER (MICRONS):

* X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 -10.13

*

5.00	*	1.1	1.1	2.8	3.6	5.7	3.6	3.1	1.9	1.9
10.00	*	5.2	5.2	7.9	9.4	17.6	9.4	9.2	8.0	8.0
15.00	*	17.7	16.9	21.4	23.6	27.2	23.6	26.0	21.6	21.6
20.00	*	29.3	29.3	32.3	35.6	34.1	35.5	40.3	34.9	34.9
25.00	*	40.7	40.7	43.7	47.3	49.6	47.3	52.3	46.7	46.7
30.00	*	50.2	50.2	54.4	57.2	63.4	57.2	59.5	55.8	55.7
35.00	*	61.2	61.2	65.1	66.0	71.5	66.0	66.2	63.5	63.5
40.00	*	69.1	69.1	73.4	72.7	75.2	72.7	72.1	69.5	69.5
45.00	*	75.1	75.1	77.1	76.3	77.8	76.3	75.7	74.3	74.3
50.00	*	78.2	78.2	78.6	78.3	79.0	78.3	78.2	77.8	77.8
55.00	*	80.1	80.1	79.9	80.3	80.0	80.3	80.4	80.1	80.1
60.00	*	81.4	81.4	81.2	81.7	81.5	81.7	82.1	81.9	81.9
65.00	*	82.7	82.7	82.9	83.2	83.6	83.2	83.4	83.2	83.2
70.00	*	84.1	84.1	84.6	84.7	85.2	84.7	84.7	84.3	84.3
75.00	*	85.6	85.6	86.1	86.0	86.4	86.0	85.8	85.5	85.5
80.00	*	86.8	86.8	87.1	86.9	87.3	86.9	86.8	86.6	86.6
85.00	*	87.6	87.6	87.8	87.7	87.9	87.7	87.7	87.5	87.5
90.00	*	88.3	88.3	88.4	88.4	88.3	88.4	88.5	88.4	88.4
95.00	*	89.0	89.0	88.8	89.0	88.9	89.0	89.1	89.1	89.1
100.00	*	89.5	89.5	89.4	89.6	89.7	89.6	89.7	89.7	89.7
105.00	*	90.1	90.1	90.2	90.2	90.3	90.2	90.2	90.1	90.1
110.00	*	90.6	90.6	90.8	90.7	90.9	90.7	90.7	90.6	90.6
115.00	*	91.2	91.2	91.3	91.2	91.4	91.2	91.1	91.1	91.1
120.00	*	91.6	91.6	91.7	91.6	91.7	91.6	91.6	91.6	91.6
125.00	*	91.9	91.9	92.0	92.0	92.0	92.0	92.1	92.0	92.0
130.00	*	92.3	92.3	92.3	92.3	92.4	92.3	92.4	92.4	92.4
135.00	*	92.7	92.7	92.7	92.7	92.7	92.7	92.5	92.6	92.6
140.00	*	93.1	93.1	93.1	93.1	93.0	93.1	93.0	93.0	93.0
145.00	*	93.3	93.3	93.4	93.4	93.3	93.4	93.4	93.3	93.3
150.00	*	93.7	93.7	93.7	93.7	93.8	93.7	93.7	93.7	93.7
155.00	*	94.0	94.0	94.0	94.0	94.1	94.0	94.0	94.0	94.0
160.00	*	94.3	94.3	94.2	94.4	94.3	94.4	94.3	94.3	94.3
165.00	*	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6
170.00	*	94.8	94.8	94.9	94.9	95.0	94.9	94.9	94.8	94.8
175.00	*	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1
180.00	*	95.3	95.3	95.4	95.4	95.4	95.4	95.4	95.4	95.4
184.99	*	95.6	95.6	95.6	95.6	95.6	95.6	95.5	95.6	95.6
189.99	*	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8	95.8
194.99	*	96.0	96.0	96.1	96.1	96.1	96.1	96.1	96.1	96.1
199.99	*	96.3	96.3	96.2	96.3	96.3	96.3	96.3	96.3	96.3

Table A12

445

ENCIRCLED ENERGY

0.25 0.25 ARC SECOND CUBE 1.0

CIRCLE *

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

RADIUS *

(MI-

CENTER (MICRONS):

CRONS)

* X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13

2.00	*	0.0	0.0	0.5	0.4	1.2	0.4	0.5	0.0	0.0
4.00	*	1.0	1.0	1.2	1.1	1.2	1.1	1.2	1.8	1.8
6.00	*	1.0	1.0	3.4	3.2	8.9	3.2	3.7	1.8	1.8
8.00	*	3.5	3.5	6.8	6.5	8.9	6.5	7.3	5.7	5.6
10.00	*	5.0	5.0	8.5	8.1	16.6	8.1	9.7	7.7	7.7
12.00	*	11.5	11.5	14.1	13.5	18.4	13.4	16.1	15.5	15.5
14.00	*	11.5	11.5	17.6	18.1	23.1	18.1	22.0	15.5	15.5
16.00	*	19.6	19.6	22.8	22.9	25.8	22.8	27.9	24.4	24.3
18.00	*	22.9	22.9	26.0	27.1	32.7	27.1	32.9	28.2	28.1
20.00	*	28.4	28.4	32.2	33.3	32.7	33.3	39.8	33.9	33.8
22.00	*	31.8	31.8	35.5	38.1	41.0	33.1	44.0	37.6	37.6
24.00	*	37.9	37.8	39.1	41.6	44.5	41.6	47.5	43.5	43.5
26.00	*	40.5	40.5	43.4	47.0	52.8	47.0	51.0	46.5	46.4
28.00	*	45.6	45.5	48.2	52.4	54.8	52.4	55.3	50.8	50.8
30.00	*	49.1	49.1	52.4	56.6	62.0	56.6	57.3	54.5	54.5
32.00	*	55.1	55.1	56.6	60.2	64.6	60.2	60.7	59.0	59.0
34.00	*	56.1	56.1	60.9	64.3	68.3	64.3	63.1	60.0	60.0
36.00	*	62.0	62.0	65.3	67.4	70.8	67.4	66.6	64.2	64.2
38.00	*	64.5	64.5	68.5	70.1	73.2	70.1	68.0	65.9	65.9
40.00	*	68.2	68.2	71.9	72.3	74.2	72.3	71.0	68.8	68.8
42.00	*	70.4	70.4	74.1	74.1	75.9	74.1	72.7	70.3	70.3
44.00	*	73.6	73.6	75.6	75.3	76.9	75.3	74.5	72.8	72.8
46.00	*	75.0	75.0	76.8	76.3	78.0	76.3	75.9	74.2	74.2
48.00	*	76.7	76.7	77.9	77.4	78.3	77.4	77.4	76.2	76.2
50.00	*	77.8	77.8	78.5	77.9	79.1	77.9	78.2	77.4	77.4
52.00	*	78.8	78.8	79.2	78.9	79.4	78.9	79.2	78.5	78.5
54.00	*	79.3	79.3	79.8	79.5	79.9	79.5	80.1	79.3	79.3
56.00	*	80.2	80.2	80.4	80.4	80.2	80.4	81.0	80.4	80.3
58.00	*	80.7	80.7	80.9	80.9	80.9	80.9	81.5	81.1	81.1
60.00	*	81.4	81.4	81.4	81.6	81.5	81.6	82.1	81.8	81.8
62.00	*	81.8	81.8	82.0	82.2	82.3	82.2	82.6	82.2	82.2
64.00	*	82.6	82.6	82.4	82.8	83.0	82.8	82.9	83.0	83.0
66.00	*	83.0	83.0	83.2	83.5	83.8	83.5	83.5	83.4	83.4
68.00	*	83.7	83.7	83.6	84.1	84.3	84.1	83.9	83.9	83.9
70.00	*	84.0	84.0	84.4	84.7	85.0	84.7	84.5	84.3	84.3
72.00	*	84.7	84.7	84.9	85.2	85.5	85.2	84.9	84.8	84.8
74.00	*	85.1	85.1	85.7	85.7	86.0	85.7	85.5	85.1	85.1
76.00	*	85.8	85.8	86.1	86.2	86.4	86.2	86.0	85.7	85.7
78.00	*	86.2	86.2	86.6	86.4	86.9	86.4	86.3	86.1	86.1
80.00	*	86.7	86.7	86.9	86.8	87.2	86.8	86.7	86.5	86.5

ORIGINAL PAGE IS
OF POOR QUALITY

ENCIRCLED ENERGY

0.7 0.25 ARC SECOND CUBE

CIRCLE	*	PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES									
RADIUS	*										
(MI-	*	CENTER (MICRONS):									
CRONS)	*	X=	-10.13	10.13	0.0	-10.13	0.0	10.13	0.0	-10.13	10.13
	*	Y=	-10.13	-10.13	-10.13	0.0	0.0	0.0	10.13	10.13	10.13
	*										

	*										
5.00	*	1.0	1.0	3.1	3.0	5.4	3.0	3.3	1.8	1.8	
10.00	*	5.0	5.0	8.5	8.1	16.6	8.1	9.7	7.7	7.7	
15.00	*	16.4	16.4	21.8	21.3	25.8	21.3	26.2	20.8	20.8	
20.00	*	28.4	28.4	32.2	33.3	32.7	33.3	39.8	33.9	33.8	
25.00	*	39.6	39.6	42.3	46.2	48.3	46.1	50.5	45.4	45.4	
30.00	*	49.1	49.1	52.4	56.6	62.0	56.6	57.3	54.5	54.5	
35.00	*	60.1	60.1	63.3	65.5	70.2	65.5	64.6	62.4	62.4	
40.00	*	68.2	68.2	71.9	72.3	74.2	72.3	71.0	68.8	68.8	
45.00	*	74.4	74.4	76.4	75.9	77.4	75.9	75.3	73.8	73.8	
50.00	*	77.8	77.8	78.5	77.9	79.1	77.9	78.2	77.4	77.4	
55.00	*	79.9	79.9	80.1	80.0	80.2	80.0	80.5	79.9	79.9	
60.00	*	81.4	81.4	81.4	81.6	81.5	81.6	82.1	81.8	81.8	
65.00	*	82.8	82.8	82.9	83.2	83.5	83.2	83.2	83.1	83.1	
70.00	*	84.0	84.0	84.4	84.7	85.0	84.7	84.5	84.3	84.3	
75.00	*	85.5	85.5	85.9	86.0	86.2	86.0	85.7	85.4	85.4	
80.00	*	86.7	86.7	86.9	86.8	87.2	86.8	86.7	86.5	86.5	
85.00	*	87.5	87.5	87.8	87.7	87.9	87.7	87.7	87.4	87.4	
90.00	*	88.2	88.2	88.4	88.3	88.4	88.3	88.5	88.3	88.3	
95.00	*	88.9	88.9	88.9	89.0	89.0	89.0	89.1	89.1	89.1	
100.00	*	89.5	89.5	89.4	89.6	89.6	89.6	89.6	89.6	89.6	
105.00	*	90.0	90.0	90.1	90.2	90.3	90.2	90.2	90.1	90.1	
110.00	*	90.6	90.6	90.7	90.7	90.9	90.7	90.7	90.6	90.6	
115.00	*	91.2	91.2	91.2	91.2	91.3	91.2	91.1	91.1	91.1	
120.00	*	91.6	91.6	91.7	91.6	91.7	91.6	91.6	91.6	91.6	
125.00	*	91.9	91.9	92.0	92.0	92.0	92.0	92.1	92.0	92.0	
130.00	*	92.3	92.3	92.3	92.3	92.4	92.3	92.4	92.4	92.4	
135.00	*	92.7	92.7	92.7	92.7	92.7	92.7	92.5	92.6	92.6	
140.00	*	93.1	93.1	93.1	93.1	93.0	93.1	93.0	93.0	93.0	
145.00	*	93.4	93.4	93.4	93.4	93.3	93.4	93.4	93.3	93.3	
150.00	*	93.7	93.7	93.7	93.7	93.8	93.7	93.7	93.7	93.7	
155.00	*	94.0	94.0	94.0	94.0	94.1	94.0	94.1	94.0	94.0	
160.00	*	94.3	94.3	94.3	94.4	94.3	94.4	94.3	94.3	94.3	
165.00	*	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	94.6	
170.00	*	94.8	94.8	94.8	94.9	94.9	94.9	94.9	94.8	94.8	
175.00	*	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	
180.00	*	95.3	95.3	95.4	95.4	95.4	95.4	95.4	95.4	95.4	
184.99	*	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	95.6	
189.99	*	95.8	95.8	95.9	95.8	95.9	95.8	95.9	95.8	95.8	
194.99	*	96.0	96.0	96.1	96.1	96.1	96.1	96.1	96.1	96.1	
199.99	*	96.3	96.3	96.2	96.3	96.3	96.3	96.3	96.4	96.4	
	*										

Table A14

A47

ENCIRCLED ENERGY

0.5 ARC SECOND CUBE

CIRCLE *
 ----- *
 RADIUS * PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES
 ----- *

(MI- * CENTER (MICRONS):
 CRONS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13
 * Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13
 *

2.00	*	0.0	0.0	0.5	0.3	1.0	0.3	0.5	0.0	0.0
4.00	*	0.9	0.9	1.1	0.8	1.0	0.8	1.1	1.6	1.6
6.00	*	0.9	0.9	3.4	2.3	7.4	2.3	3.6	1.6	1.6
8.00	*	3.1	3.1	6.5	4.9	7.4	4.9	6.9	5.0	5.0
10.00	*	4.5	4.5	8.1	6.2	13.8	6.2	9.2	6.8	6.8
12.00	*	10.3	10.3	13.1	10.6	15.3	10.6	15.0	13.9	13.8
14.00	*	10.3	10.3	16.2	14.9	19.5	14.8	20.1	13.9	13.8
16.00	*	17.7	17.7	21.0	18.9	21.8	18.9	25.6	21.8	21.8
18.00	*	20.7	20.7	23.8	23.2	28.5	23.2	29.8	25.3	25.3
20.00	*	25.9	25.8	29.5	28.7	28.5	28.7	36.2	30.6	30.6
22.00	*	28.9	28.9	32.3	34.0	36.8	33.9	39.7	34.0	34.0
24.00	*	34.6	34.6	35.9	37.1	40.2	37.0	43.2	39.6	39.6
26.00	*	37.1	37.1	39.6	43.0	48.5	42.9	46.2	42.5	42.5
28.00	*	42.1	42.1	44.5	48.5	50.5	48.5	50.7	46.9	46.9
30.00	*	45.7	45.6	48.3	53.1	57.7	53.1	52.7	50.7	50.7
32.00	*	51.8	51.8	52.7	56.7	60.3	56.7	56.5	55.6	55.6
34.00	*	52.8	52.8	56.8	61.3	64.3	61.3	59.1	56.7	56.7
36.00	*	58.9	58.9	61.5	64.5	67.0	64.5	63.2	61.3	61.3
38.00	*	61.5	61.5	64.8	67.5	70.0	67.5	65.0	63.2	63.2
40.00	*	65.4	65.4	68.5	69.9	71.3	69.9	68.5	66.5	66.5
42.00	*	67.7	67.7	71.1	72.1	73.8	72.1	70.6	68.2	68.2
44.00	*	71.1	71.1	73.0	73.4	75.1	73.4	72.8	70.9	70.9
46.00	*	72.8	72.8	74.8	74.8	77.1	74.8	74.6	72.6	72.6
48.00	*	74.9	74.8	76.3	76.2	77.6	76.2	76.4	74.8	74.8
50.00	*	76.2	76.2	77.3	76.9	78.9	76.9	77.4	76.2	76.2
52.00	*	77.5	77.5	78.4	78.1	79.4	78.1	78.6	77.5	77.5
54.00	*	78.2	78.2	79.4	79.0	80.1	79.0	79.6	78.5	78.5
56.00	*	79.5	79.5	80.4	80.1	80.4	80.1	80.6	79.6	79.6
58.00	*	80.3	80.3	81.0	80.7	81.1	80.7	81.2	80.5	80.5
60.00	*	81.1	81.1	81.5	81.5	81.6	81.5	81.7	81.3	81.3
62.00	*	81.6	81.6	82.1	82.1	82.3	82.1	82.3	81.8	81.8
64.00	*	82.5	82.5	82.4	82.7	82.8	82.7	82.6	82.6	82.6
66.00	*	82.9	82.9	83.1	83.3	83.5	83.3	83.2	83.1	83.1
68.00	*	83.6	83.6	83.5	83.8	83.9	83.8	83.6	83.7	83.7
70.00	*	83.9	83.9	84.1	84.4	84.5	84.4	84.2	84.1	84.1
72.00	*	84.6	84.6	84.6	84.9	85.0	84.9	84.7	84.7	84.7
74.00	*	84.9	84.9	85.3	85.4	85.5	85.4	85.3	85.0	85.0
76.00	*	85.5	85.5	85.7	85.9	85.9	85.9	85.7	85.5	85.5
78.00	*	85.9	85.9	86.2	86.2	86.5	86.2	86.1	85.9	85.9
80.00	*	86.4	86.4	86.5	86.6	86.9	86.6	86.6	86.4	86.4

0.5 0.5 ARC SECOND CUBE

.....

* PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

* 11

* CENTER (MICRONS):

```
* X= -10.13  10.13   0.0 -10.13   0.0  10.13   0.0 -10.13  10.13
```

$$* Y = -10.13 \quad -10.13 \quad -10.13 \quad 0.0 \quad 0.0 \quad 0.0 \quad 10.13 \quad 10.13 \quad 10.13$$
[illegible][illegible]

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Table A16

449

ENCIRCLED ENERGY

0.7 - 0.75 ARC SECOND CUBE

CIRCLE *
 ----- * PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES
 RADIUS *
 ----- *

(MI- * CENTER (MICRONS):

CRONS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 -10.13 10.13

*

2.00	*	0.0	0.0	0.4	0.1	0.7	0.1	0.4	0.0	0.0
4.00	*	0.7	0.7	0.9	0.5	0.7	0.5	0.9	1.3	1.3
6.00	*	0.7	0.7	2.9	1.5	5.3	1.5	3.1	1.3	1.3
8.00	*	2.6	2.6	5.4	3.3	5.3	3.3	5.8	4.2	4.1
10.00	*	3.7	3.7	6.9	4.2	9.9	4.2	7.8	5.7	5.6
12.00	*	8.7	8.7	11.0	7.5	11.1	7.5	12.5	11.5	11.5
14.00	*	8.7	8.7	13.5	11.1	14.4	11.1	16.7	11.5	11.5
16.00	*	14.9	14.9	17.6	14.3	16.4	14.3	21.3	18.2	18.1
18.00	*	17.4	17.4	19.9	18.3	22.6	18.2	24.8	21.1	21.1
20.00	*	22.0	22.0	24.9	22.8	22.6	22.8	30.3	25.8	25.8
22.00	*	24.5	24.5	27.3	28.1	30.6	28.0	33.3	28.7	28.7
24.00	*	29.7	29.6	30.8	30.7	33.9	30.7	36.6	33.8	33.8
26.00	*	31.9	31.9	34.2	36.7	41.9	36.7	39.4	36.5	36.4
28.00	*	36.9	36.9	39.1	42.2	43.8	42.2	44.2	41.0	41.0
30.00	*	40.3	40.3	42.5	47.0	50.9	47.0	46.2	44.8	44.8
32.00	*	46.5	46.5	47.2	50.6	53.5	50.6	50.6	50.1	50.1
34.00	*	47.6	47.6	51.1	55.7	57.6	55.7	53.5	51.3	51.3
36.00	*	54.0	53.9	55.9	59.0	60.8	59.0	58.1	56.4	56.4
38.00	*	56.6	56.6	59.4	62.4	64.5	62.4	60.5	58.7	58.7
40.00	*	60.9	60.9	63.2	65.2	66.3	65.2	64.4	62.5	62.5
42.00	*	63.2	63.2	66.3	68.2	69.9	68.2	67.1	64.4	64.4
44.00	*	67.0	67.0	68.6	69.7	71.9	69.7	69.6	67.6	67.6
46.00	*	69.0	69.0	71.0	72.0	74.9	72.0	71.9	69.6	69.6
48.00	*	71.5	71.5	73.3	73.9	75.6	73.9	74.1	72.2	72.2
50.00	*	73.3	73.3	74.7	75.1	77.8	75.1	75.3	73.9	73.9
52.00	*	75.2	75.2	76.5	76.8	78.6	76.8	77.0	75.5	75.5
54.00	*	76.2	76.2	78.0	78.0	79.7	78.0	78.1	76.7	76.7
56.00	*	78.0	78.0	79.6	79.4	80.2	79.4	79.5	78.2	78.2
58.00	*	79.2	79.2	80.4	80.1	81.0	80.1	80.2	79.2	79.2
60.00	*	80.3	80.3	81.3	81.0	81.5	81.0	81.0	80.2	80.2
62.00	*	81.0	81.0	81.9	81.7	82.1	81.7	81.6	80.9	80.9
64.00	*	82.1	82.1	82.3	82.3	82.6	82.3	82.2	81.9	81.9
66.00	*	82.6	82.6	82.9	82.9	83.1	82.9	82.8	82.5	82.5
68.00	*	83.3	83.3	83.3	83.4	83.5	83.4	83.3	83.2	83.2
70.00	*	83.6	83.6	83.9	83.9	84.1	83.9	83.9	83.7	83.7
72.00	*	84.3	84.3	84.2	84.4	84.4	84.4	84.4	84.3	84.3
74.00	*	84.6	84.6	84.8	84.9	84.9	84.9	85.0	84.7	84.7
76.00	*	85.1	85.1	85.2	85.4	85.3	85.4	85.5	85.3	85.3
78.00	*	85.5	85.5	85.6	85.7	85.9	85.7	85.8	85.7	85.7
80.00	*	86.0	86.0	86.0	86.2	86.4	86.2	86.3	86.1	86.1

*

ORIGINAL PAGE IS
 OF POOR QUALITY

Table A17

A50

ENCIRCLED ENERGY

0.75

0.75 ARC SECOND CUBE

CIRCLE *
 * PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES
 RADIUS *

(MI- * CENTER (MICRONS):
 CRONS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13
 * Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13
 *

5.00	*	0.7	0.7	2.4	1.4	3.2	1.4	2.6	1.3	1.3
10.00	*	3.7	3.7	6.9	4.2	9.9	4.2	7.8	5.7	5.6
15.00	*	12.4	12.4	16.9	13.0	16.4	13.0	20.1	15.5	15.4
20.00	*	22.0	22.0	24.9	22.8	22.6	22.8	30.3	25.8	25.8
25.00	*	31.2	31.2	33.1	36.0	37.6	36.0	38.8	35.6	35.5
30.00	*	40.3	40.3	42.5	47.0	50.9	47.0	46.2	44.8	44.8
35.00	*	51.7	51.7	53.8	56.7	60.0	56.7	55.7	54.3	54.3
40.00	*	60.9	60.9	63.2	65.2	66.3	65.2	64.4	62.5	62.5
45.00	*	68.2	68.2	70.0	71.2	73.5	71.2	70.9	69.0	69.0
50.00	*	73.3	73.3	74.7	75.1	77.8	75.1	75.3	73.9	73.9
55.00	*	77.4	77.4	78.8	78.8	80.1	78.8	78.9	77.5	77.5
60.00	*	80.3	80.3	81.3	81.0	81.5	81.0	81.0	80.2	80.2
65.00	*	82.3	82.3	82.7	82.6	82.9	82.6	82.5	82.2	82.2
70.00	*	83.6	83.6	83.9	83.9	84.0	83.9	83.9	83.7	83.7
75.00	*	84.9	84.9	85.0	85.2	85.1	85.2	85.2	85.0	85.0
80.00	*	86.0	86.0	86.0	86.2	86.4	86.2	86.3	86.1	86.1
85.00	*	86.9	86.9	87.2	87.3	87.6	87.3	87.3	87.0	87.0
90.00	*	87.8	87.8	88.1	88.1	88.3	88.1	88.1	87.9	87.9
95.00	*	88.7	88.7	88.9	88.8	88.9	88.8	88.8	88.7	88.7
100.00	*	89.4	89.4	89.4	89.4	89.5	89.4	89.4	89.4	89.4
105.00	*	89.9	89.9	90.0	90.0	90.0	90.0	90.1	89.9	89.9
110.00	*	90.4	90.4	90.5	90.5	90.6	90.5	90.6	90.5	90.5
115.00	*	91.0	91.0	90.9	91.0	91.1	91.0	91.0	91.1	91.1
120.00	*	91.4	91.4	91.4	91.5	91.6	91.5	91.5	91.5	91.5
125.00	*	91.8	91.8	92.0	91.9	92.0	91.9	91.9	91.9	91.9
130.00	*	92.2	92.2	92.3	92.3	92.4	92.3	92.3	92.3	92.3
135.00	*	92.6	92.6	92.6	92.6	92.7	92.6	92.6	92.6	92.6
140.00	*	93.0	93.0	93.0	93.0	92.9	93.0	93.0	92.9	92.9
145.00	*	93.3	93.3	93.4	93.3	93.2	93.3	93.3	93.3	93.3
150.00	*	93.7	93.7	93.7	93.7	93.7	93.7	93.6	93.6	93.6
155.00	*	93.9	93.9	94.0	94.0	94.1	94.0	94.0	93.9	93.9
160.00	*	94.3	94.3	94.2	94.3	94.3	94.3	94.3	94.3	94.3
165.00	*	94.5	94.5	94.6	94.6	94.6	94.6	94.6	94.6	94.6
170.00	*	94.8	94.8	94.8	94.9	94.9	94.9	94.8	94.8	94.8
175.00	*	95.1	95.1	95.1	95.1	95.0	95.1	95.1	95.1	95.1
180.00	*	95.4	95.4	95.4	95.4	95.4	95.4	95.4	95.3	95.3
184.99	*	95.6	95.6	95.6	95.6	95.6	95.6	95.5	95.6	95.6
189.99	*	95.8	95.8	95.9	95.8	95.9	95.8	95.9	95.8	95.8
194.99	*	96.0	96.0	96.1	96.1	96.2	96.1	96.1	96.0	96.0
199.99	*	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3	96.3

ORIGINAL PAGE IS
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Wavefront Map - Q Polarization

Cube #1

MAP IN UNITS OF 0.01 WAVES

[illegible]

Figure A34

Wavefront Plot - Q Polarization

Cube #1

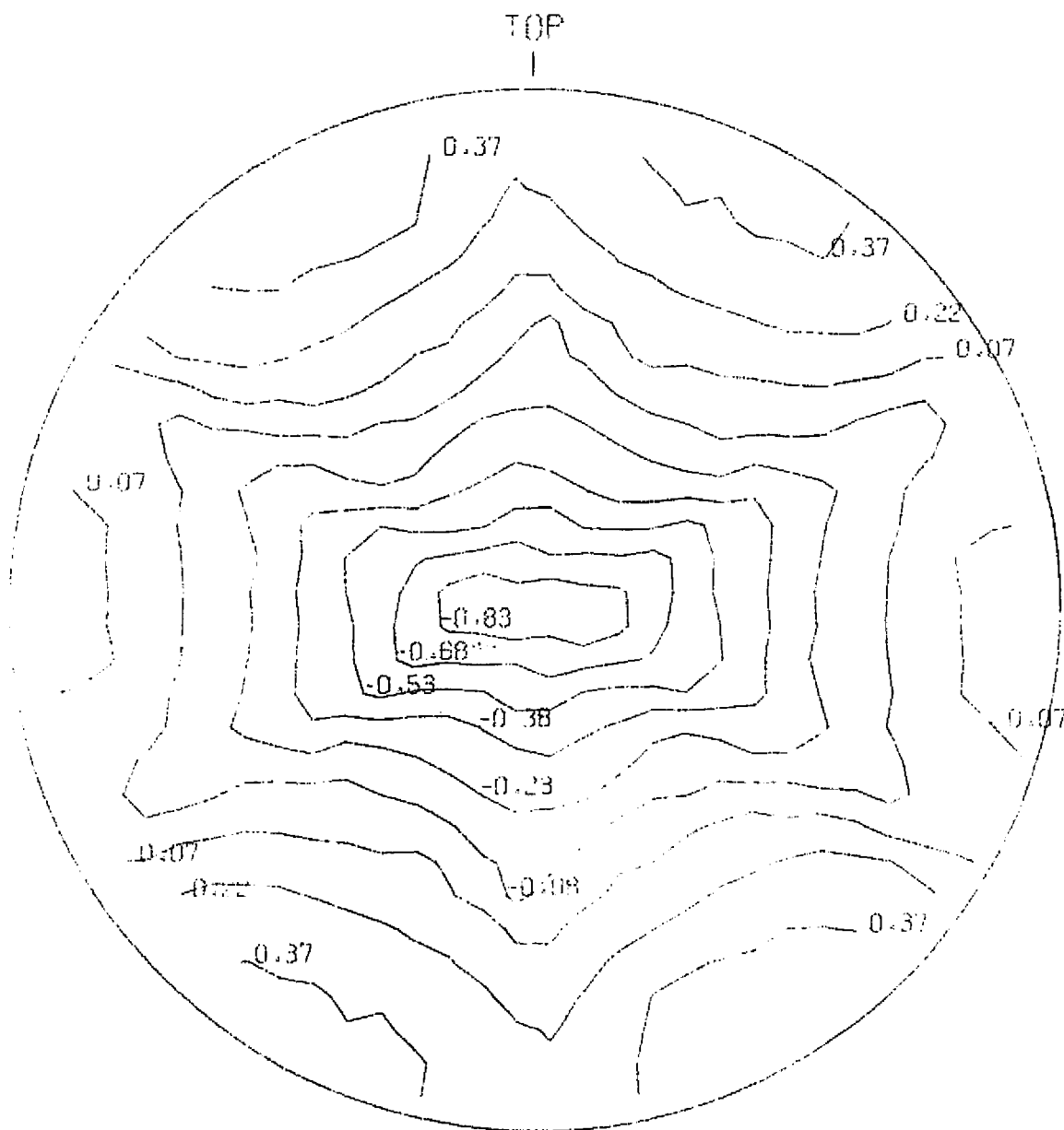


Figure A35

Wavefront Map - P Polarization

Cube #1

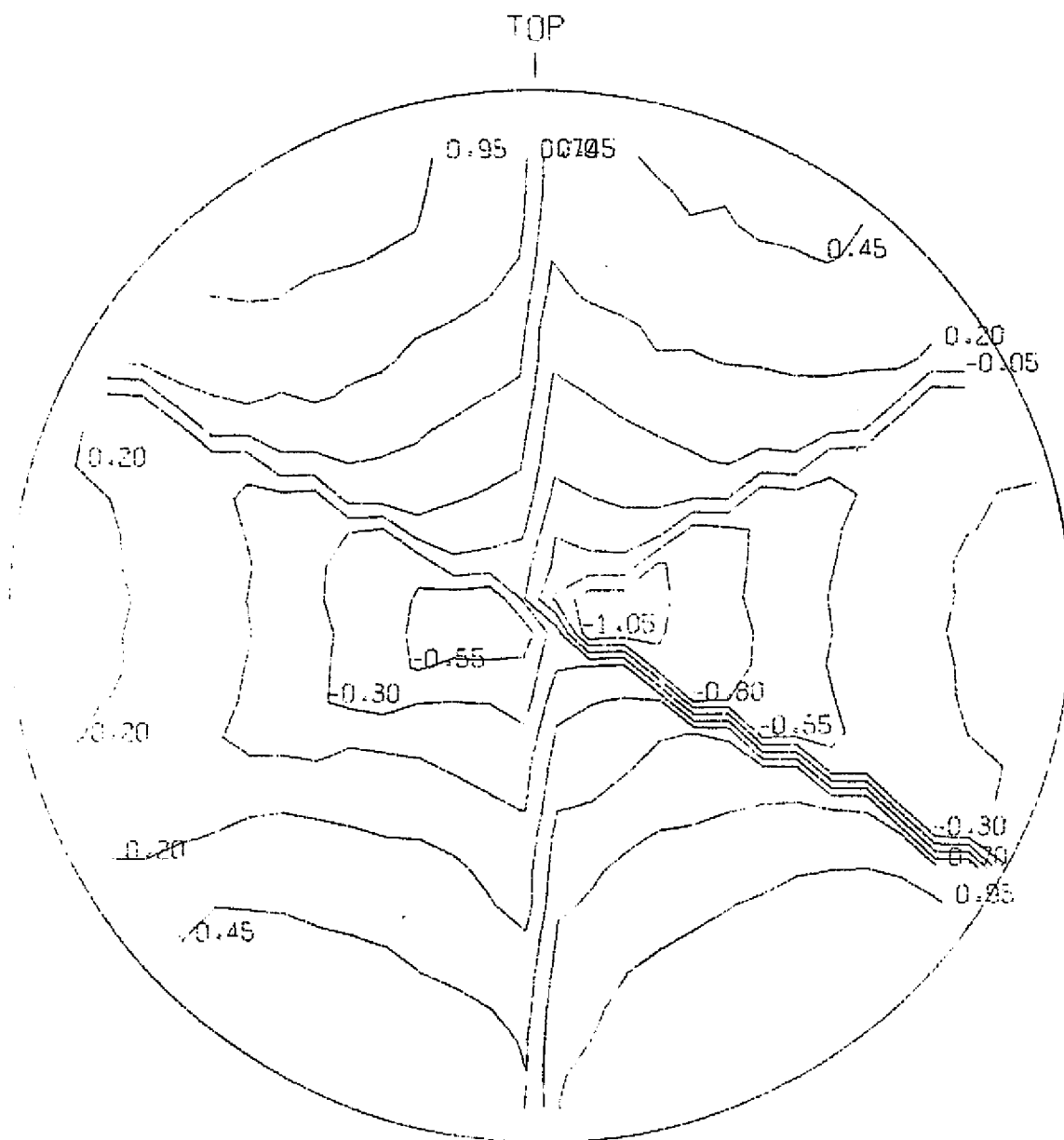
MAP IN UNITS OF -0.01 WAVES

[illegible]

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Figure A36
Wavefront Plot - P Polarization

Cube #1



ORIGINAL PAGE IS
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PRINTED MAP OF PRINT SPEED FUNCTION--

001-4120-0-307VA 15-DAY-15-03247PWETH

TOTAL ENERGY = 0.24610000+01

MAP REPRESENTS	0.2323806D+01	94.4253 PERCENT OF TOTAL ENERGY.
1	0.2323806D+01	94.4253 PERCENT OF TOTAL ENERGY.

[illegible]

Figure A38

Point Spread Function

Cube #1

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OF POOR QUALITY

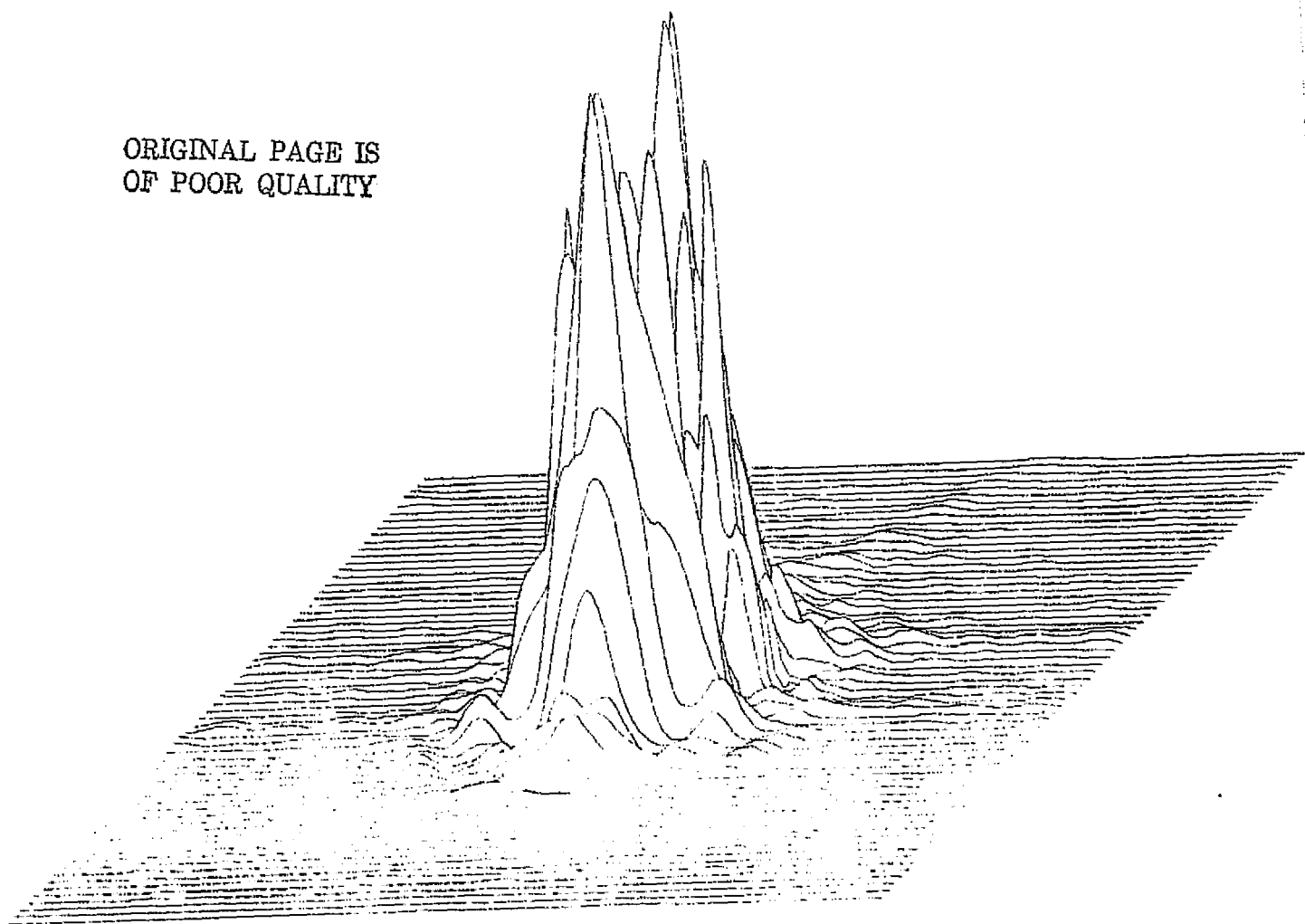
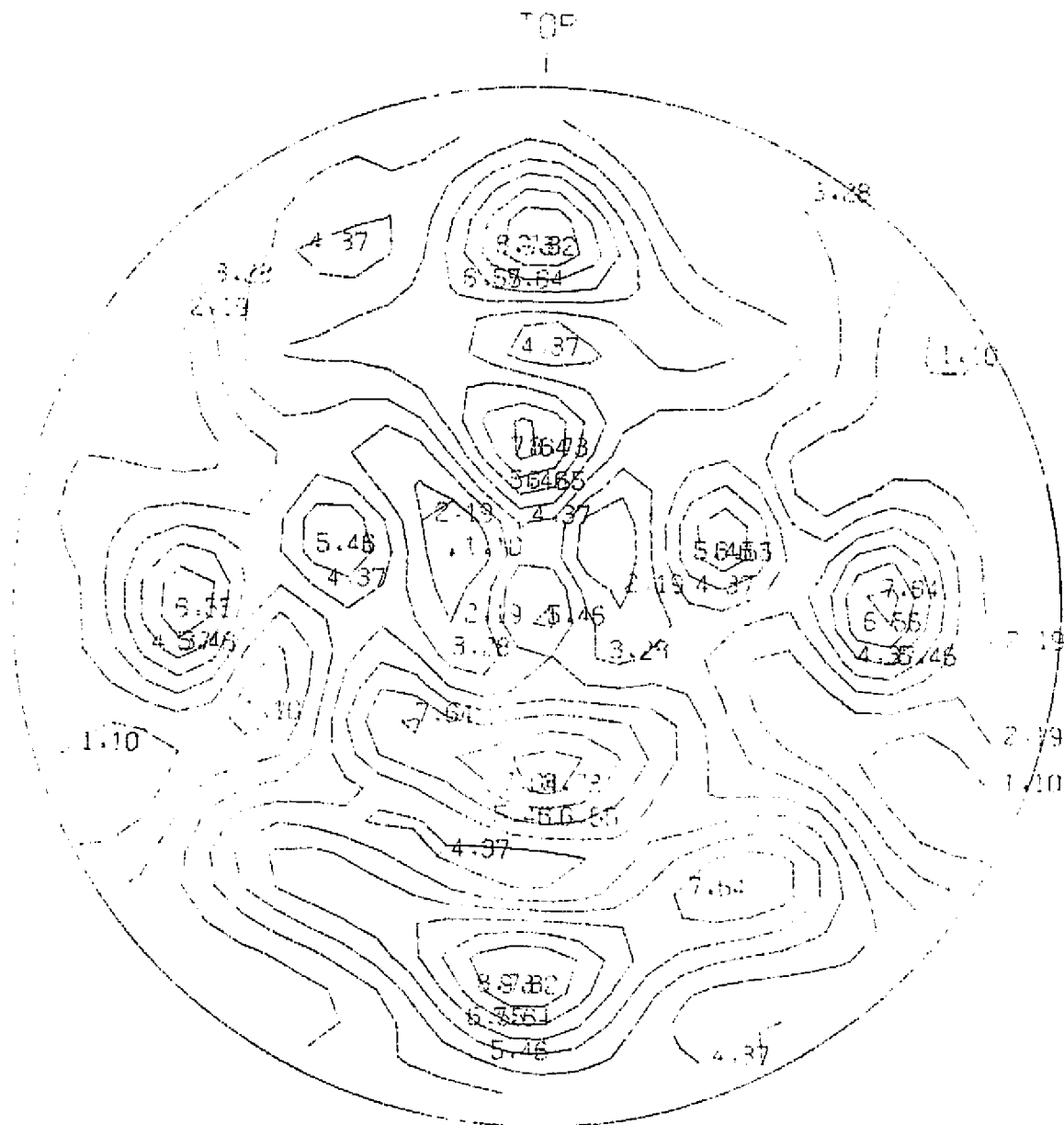


Figure A39

Intensity Distribution - Central 129 Microradians

Cube #1



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OF POOR QUALITY

Figure A40
Encircled Energy
Vs
Field Angle
Cube #1

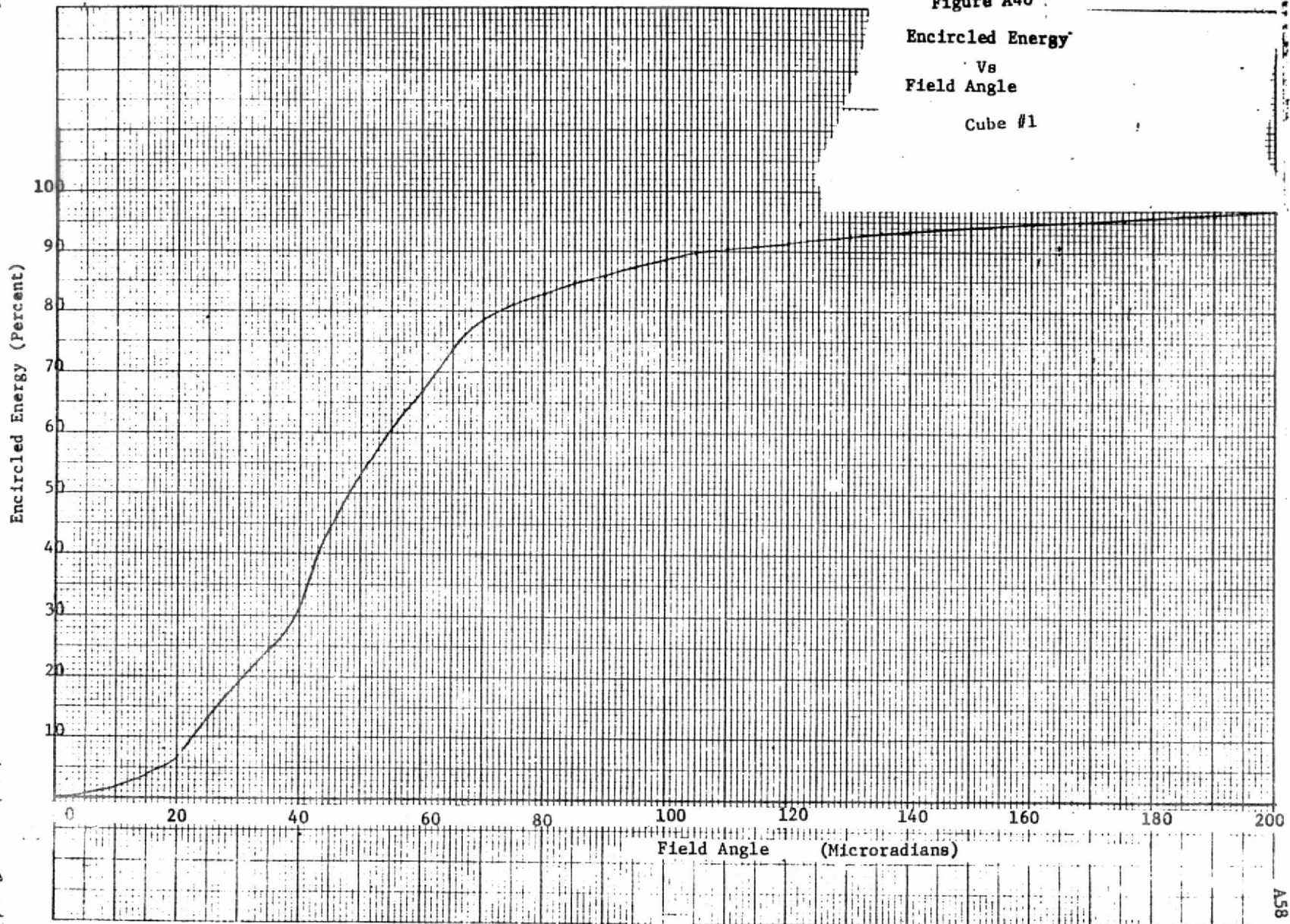


Table A18

A59

ENCIRCLED ENERGY

Cube #1

CIRCLE

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

RADIUS

(MT- CENTER (MICRONS):

COORDS) X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13

2.00	*	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0
4.00	*	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.4	0.4
6.00	*	0.2	0.2	0.7	0.4	0.9	0.4	0.8	0.4	0.4
8.00	*	0.7	0.7	1.3	0.8	0.9	0.9	1.5	1.3	1.3
10.00	*	1.1	1.1	1.6	1.1	1.6	1.2	2.0	1.9	1.9
12.00	*	2.3	2.0	2.6	2.0	1.8	2.1	3.2	3.8	3.6
14.00	*	2.8	2.0	3.3	3.3	2.8	3.3	4.6	3.8	3.6
16.00	*	5.0	5.2	4.4	4.3	3.4	4.3	5.8	5.9	5.6
18.00	*	5.9	6.1	5.5	5.8	6.3	5.7	7.1	6.9	6.6
20.00	*	7.7	7.8	7.1	7.4	6.3	7.3	8.6	8.5	8.3
22.00	*	9.5	8.6	8.8	9.3	10.0	9.2	10.1	9.3	9.2
24.00	*	10.8	10.7	10.3	10.5	11.4	10.4	11.4	11.4	11.5
26.00	*	11.8	11.7	12.6	12.7	14.8	12.6	13.1	12.5	12.8
28.00	*	14.9	14.6	15.9	15.4	15.7	15.5	16.3	15.4	15.9
30.00	*	17.0	16.6	18.0	17.5	18.6	17.5	18.0	17.6	18.2
32.00	*	21.4	20.9	21.2	19.9	20.1	20.1	21.3	21.8	22.5
34.00	*	22.4	21.9	23.7	22.8	22.3	23.0	24.0	22.8	23.5
36.00	*	27.0	26.6	26.9	25.5	24.9	25.7	27.8	27.4	28.0
38.00	*	29.1	29.7	29.4	28.5	29.1	28.7	30.5	29.7	30.2
40.00	*	32.8	32.4	32.5	31.3	31.1	31.5	34.2	33.5	34.0
42.00	*	34.6	34.2	35.8	35.5	37.1	35.5	37.7	35.4	35.8
44.00	*	38.3	38.0	38.4	37.6	39.7	37.6	40.6	39.3	37.6
46.00	*	40.7	40.4	41.0	42.4	45.9	42.3	44.0	42.0	42.2
48.00	*	44.3	43.0	45.9	46.0	47.1	45.9	47.9	45.6	45.9
50.00	*	47.1	46.7	48.4	49.3	52.6	49.2	50.1	48.6	49.8
52.00	*	51.0	50.5	52.5	53.0	54.6	52.8	53.9	52.3	52.6
54.00	*	53.2	52.8	55.3	56.5	58.5	56.3	56.4	54.5	54.7
56.00	*	57.3	57.0	59.6	60.1	60.5	60.0	60.5	58.4	58.6
58.00	*	60.1	59.9	61.6	62.5	64.3	62.4	62.5	61.1	61.2
60.00	*	63.2	63.1	65.0	65.4	66.6	65.5	65.8	64.1	64.1
62.00	*	65.2	65.2	67.0	68.3	69.6	68.3	67.9	65.1	66.0
64.00	*	68.3	68.6	69.4	70.0	71.9	70.1	70.3	69.2	68.9
66.00	*	70.1	70.3	71.5	72.0	74.8	72.9	72.5	70.9	70.6
68.00	*	72.4	72.9	73.7	74.4	75.9	74.4	74.4	73.3	73.0
70.00	*	73.8	74.1	75.4	76.4	78.2	76.5	75.9	74.6	74.3
72.00	*	76.0	76.4	77.2	77.7	79.4	77.3	77.5	76.7	76.4
74.00	*	77.1	77.4	78.8	79.4	80.7	79.4	78.8	77.6	77.4
76.00	*	79.0	79.3	80.4	80.6	81.4	80.5	80.2	79.4	79.2
78.00	*	80.2	80.4	81.1	81.6	82.3	81.6	80.8	80.3	80.2
80.00	*	81.5	81.7	82.4	82.4	82.9	82.5	82.1	81.7	81.5

Table A19

A60

ENCIRCLED ENERGY

Cube #1

CIRCLE

RADIUS

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

(MT- * CENTER (MICRONS):

COVS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 10.13 0.0 0.0 0.0 0.0 10.13 10.13

5.00	*	0.2	0.2	0.5	0.3	0.6	0.3	0.6	0.4	0.4
10.00	*	1.1	1.1	1.6	1.1	1.6	1.2	2.0	1.9	1.8
15.00	*	4.1	4.3	4.1	3.8	3.4	3.8	5.4	5.0	4.8
20.00	*	7.7	7.8	7.1	7.4	6.3	7.3	8.6	8.5	8.3
25.00	*	11.5	11.4	12.1	12.4	13.0	12.4	12.8	12.1	12.4
30.00	*	17.0	16.6	18.0	17.5	18.6	17.5	18.0	17.6	18.2
35.00	*	25.2	24.8	25.4	23.8	24.2	24.0	25.7	25.5	26.1
40.00	*	32.8	32.4	32.5	31.3	31.1	31.5	34.2	33.5	34.0
45.00	*	39.7	39.3	40.3	40.8	43.7	40.7	42.5	40.8	41.1
50.00	*	47.1	46.7	48.4	49.3	52.6	49.2	50.1	48.6	48.8
55.00	*	55.9	55.5	57.9	59.4	60.1	58.3	59.0	56.9	57.2
60.00	*	63.7	63.1	65.0	65.4	66.6	65.5	65.8	64.1	64.1
65.00	*	69.1	69.4	70.7	71.7	73.7	71.8	71.6	70.0	69.7
70.00	*	73.8	74.1	75.4	76.4	78.2	76.5	75.9	74.6	74.3
75.00	*	78.2	78.5	79.6	80.0	81.1	80.0	79.6	78.6	78.4
80.00	*	81.5	81.7	82.4	82.4	82.9	82.5	82.1	81.7	81.5
85.00	*	83.6	83.9	84.2	84.3	84.3	84.3	84.2	83.8	83.7
90.00	*	85.3	85.4	85.5	85.7	85.8	85.8	85.8	85.6	85.4
95.00	*	86.7	86.8	86.8	87.0	87.2	87.0	87.1	87.0	86.9
100.00	*	87.9	87.9	88.0	88.2	88.5	88.2	88.2	88.0	88.0
105.00	*	88.9	88.9	89.2	89.3	89.5	89.3	89.1	88.9	89.0
110.00	*	90.0	90.9	90.1	90.1	90.3	90.1	89.9	89.8	89.8
115.00	*	90.8	90.7	90.8	90.8	90.9	90.9	90.9	90.7	90.7
120.00	*	91.4	91.4	91.5	91.4	91.4	91.4	91.5	91.4	91.3
125.00	*	91.9	91.9	92.0	92.0	92.0	91.9	92.1	92.0	91.9
130.00	*	92.5	92.5	92.5	92.5	92.6	92.5	92.6	92.5	92.5
135.00	*	92.9	92.9	93.0	93.0	93.2	93.0	93.0	93.0	92.9
140.00	*	93.3	93.4	93.4	93.5	93.5	93.5	93.5	93.5	93.4
145.00	*	93.7	93.7	93.7	93.9	93.8	93.9	93.9	93.8	93.8
150.00	*	94.1	94.0	94.1	94.2	94.2	94.2	94.2	94.2	94.2
155.00	*	94.4	94.4	94.5	94.5	94.5	94.5	94.5	94.4	94.5
160.00	*	94.7	94.7	94.7	94.7	94.7	94.7	94.7	94.8	94.8
165.00	*	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0
170.00	*	95.2	95.3	95.3	95.3	95.3	95.3	95.3	95.3	95.3
175.00	*	95.5	95.5	95.5	95.6	95.6	95.6	95.6	95.6	95.5
180.00	*	95.8	95.8	95.8	95.8	95.9	95.8	95.9	95.8	95.8
184.99	*	96.0	96.0	96.0	96.0	96.1	96.1	96.1	96.1	96.1
189.99	*	96.2	96.2	96.3	96.3	96.3	96.3	96.3	96.3	96.3
194.99	*	96.4	96.4	96.4	96.5	96.5	96.5	96.5	96.5	96.5
199.99	*	96.7	96.7	96.6	96.7	96.7	96.7	96.7	96.7	96.7

ORIGINAL PAGE IS
OF POOR QUALITY

A61

Cuba #2

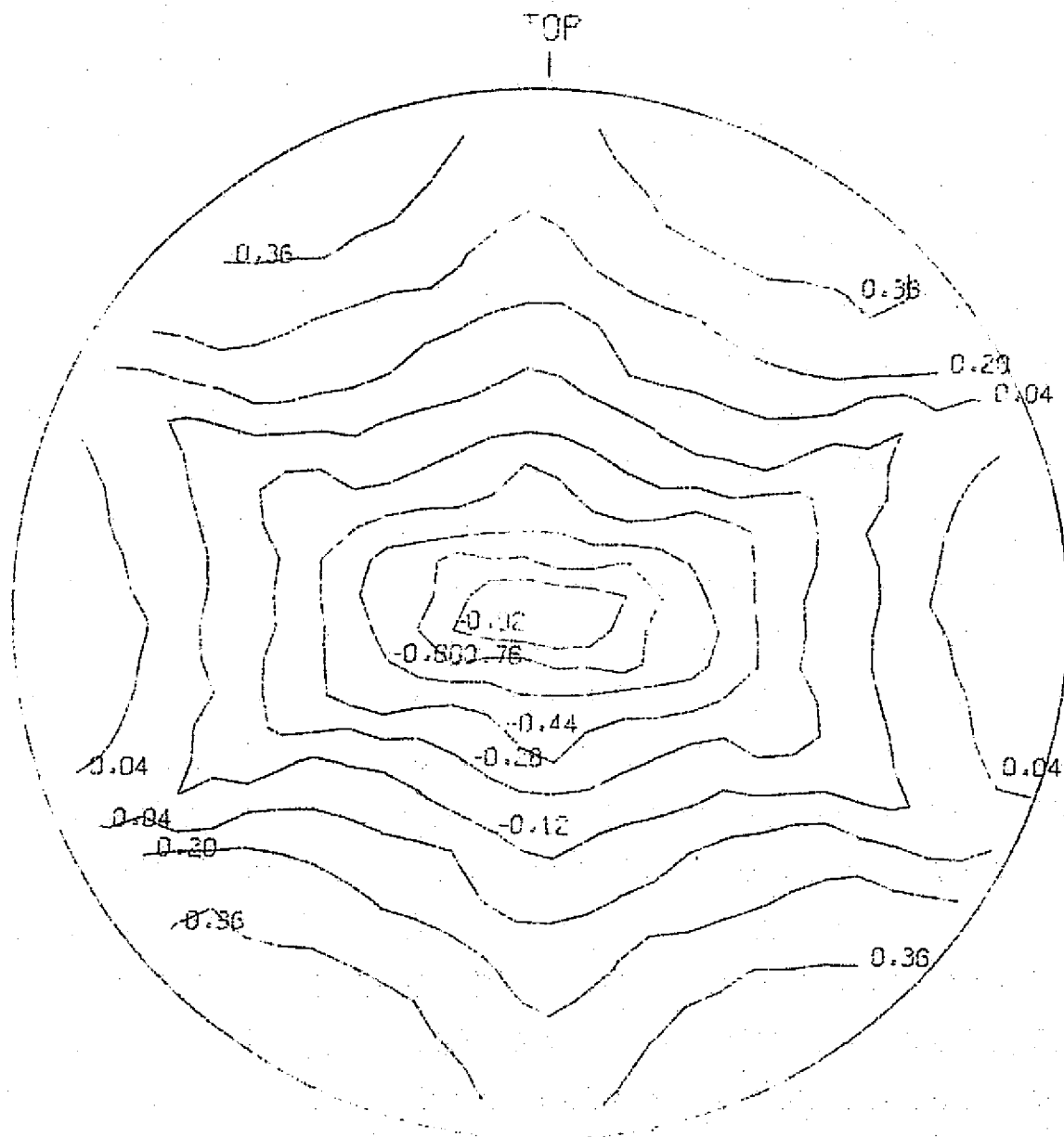
-MAP- IN UNITS OF- 0.01 WAVES

[illegible]

ORIGINAL PAGE IS
OF POOR QUALITY

Figure A42

Wavefront Plot - Q Polarization
Cube #2



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OF POOR QUALITY

Cube #2

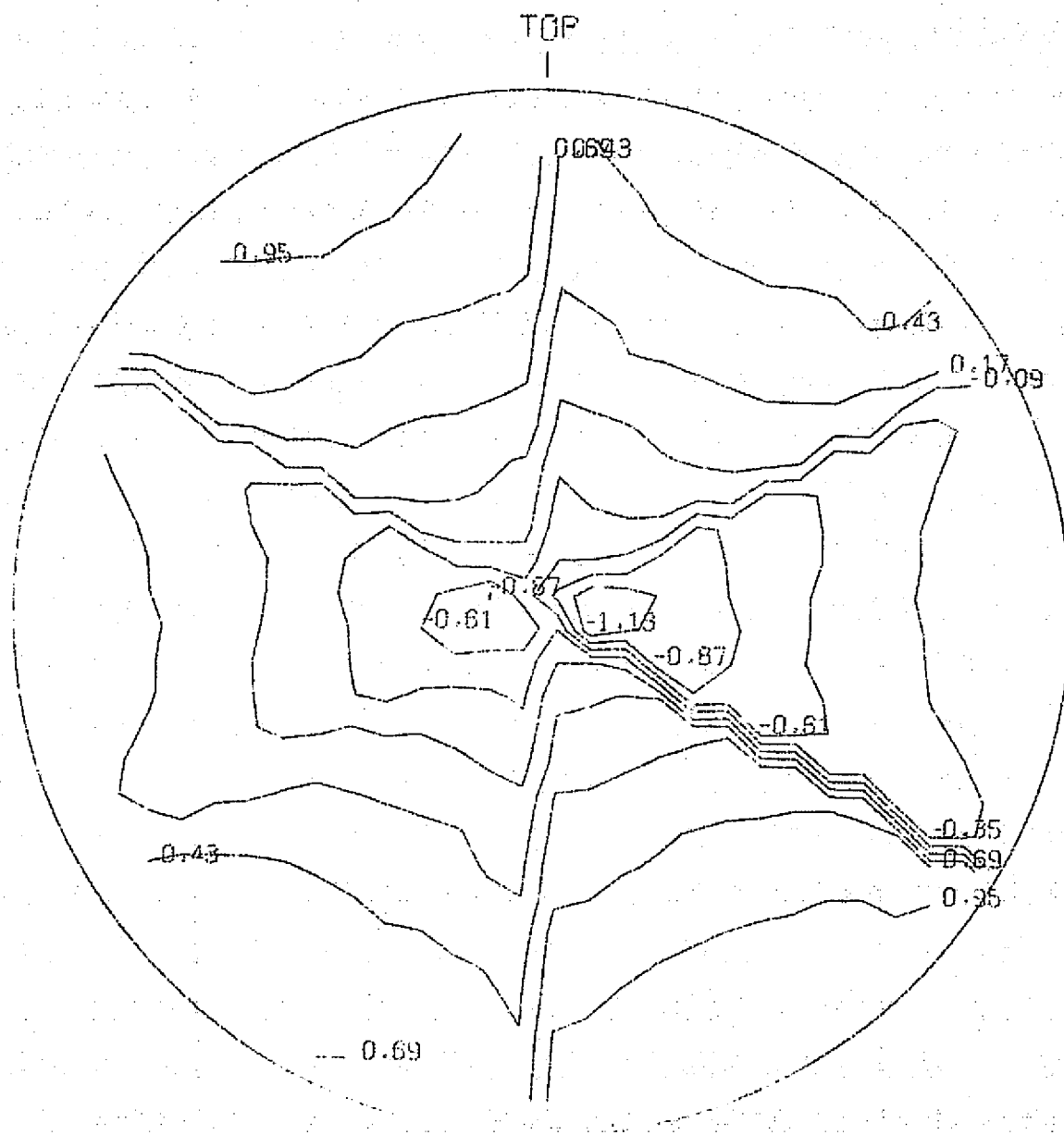
- MAP IN UNITS OF 0.01 WAVES

[illegible]

Figure A44

Wavefront Plot - P Polarization

Cube #2



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OF POOR QUALITY

Figure A46

Point Spread Function
Cube #2

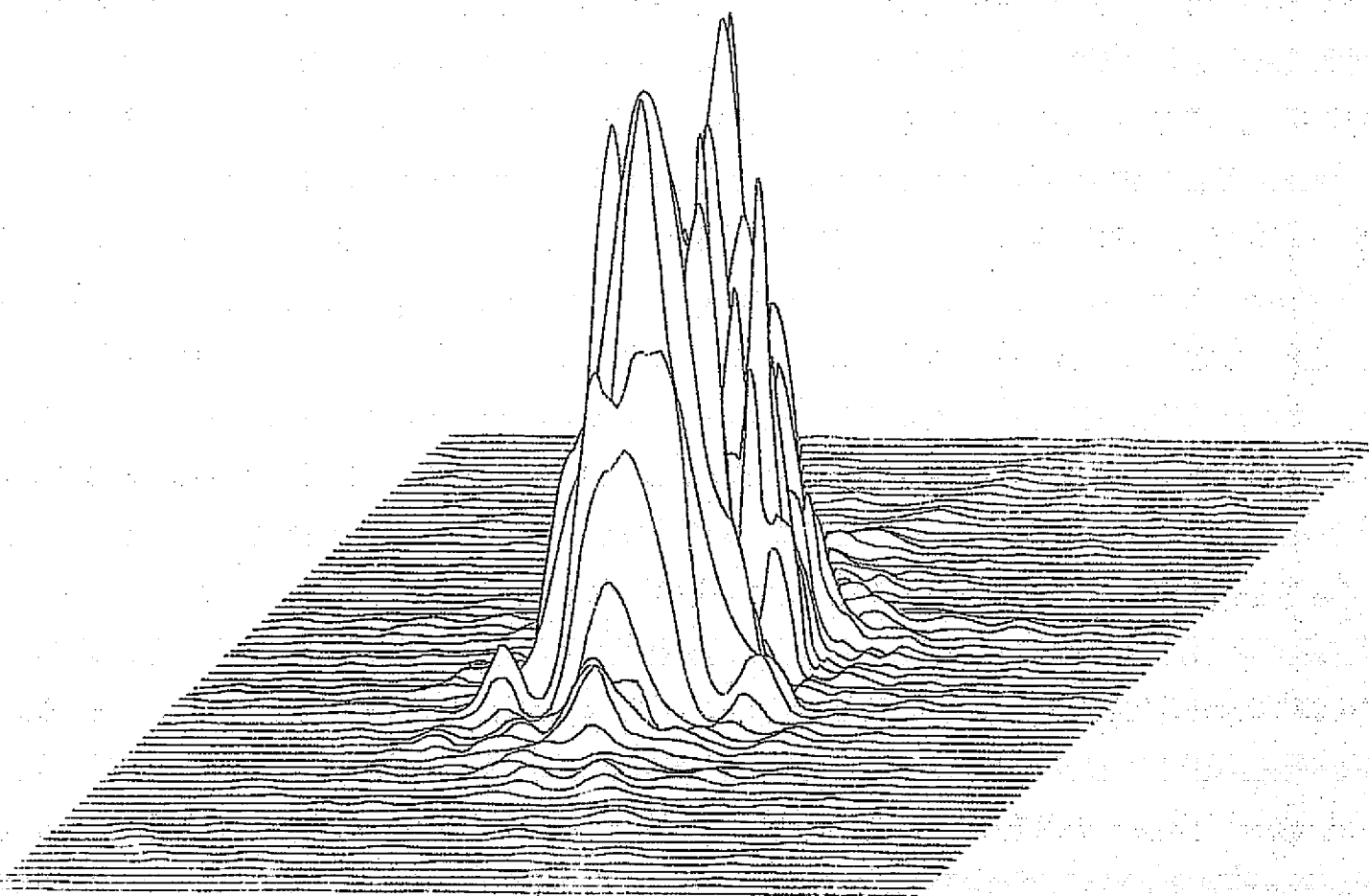
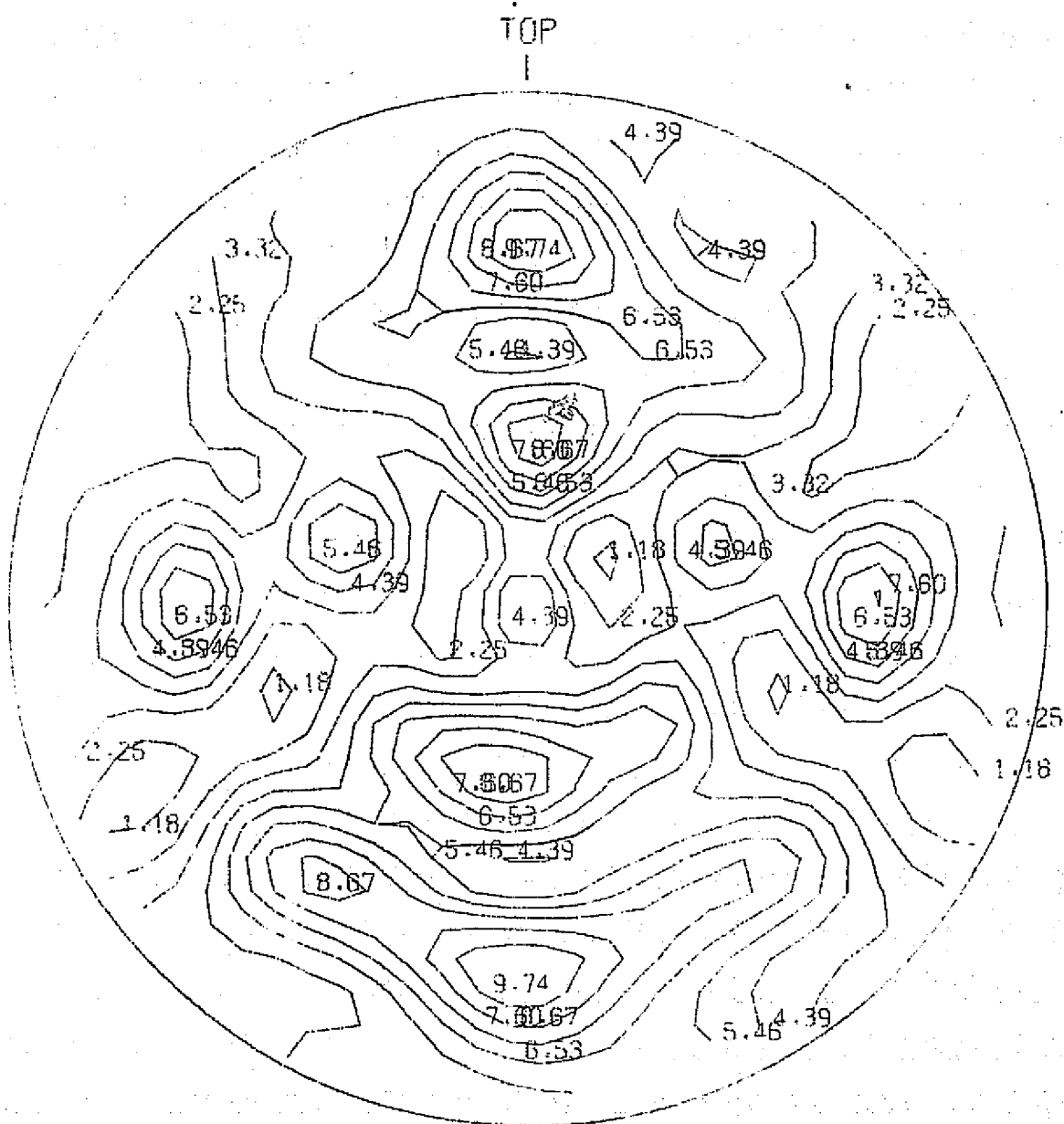


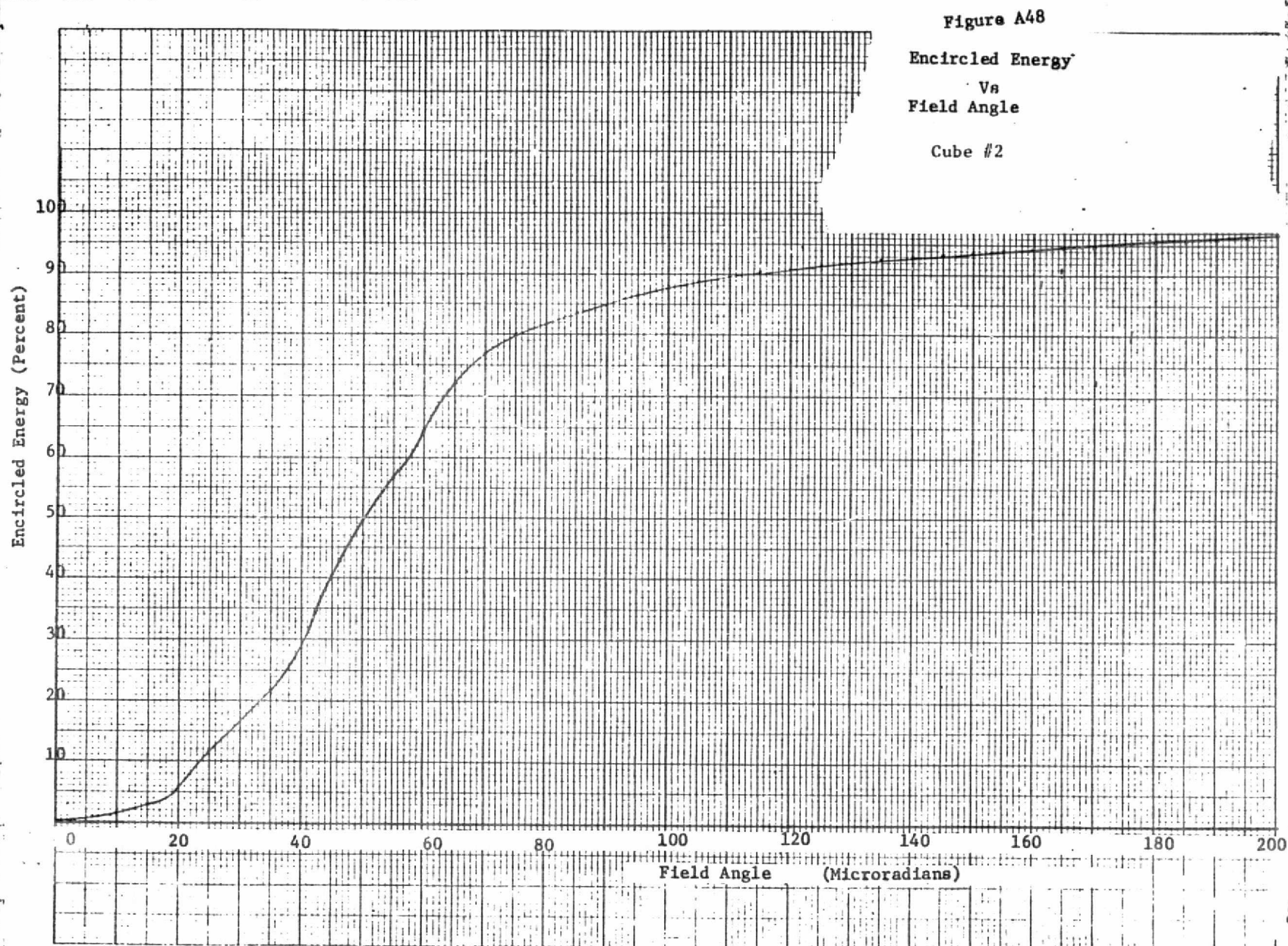
Figure A47

Intensity Distribution - Central 129 Microradians

Cube #2



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OF POOR QUALITY



ENCIRCLED ENERGY

Cube #2

CIRCLE

RADIUS

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

(MI- CENTER (MICRONS):

CROSS) X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13

2.00	*	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0
4.00	*	0.1	0.2	0.2	0.1	0.1	0.1	0.2	0.4	0.4
6.00	*	0.1	0.2	0.6	0.3	0.8	0.3	0.7	0.4	0.4
8.00	*	0.6	0.7	1.1	0.7	0.8	0.7	1.3	1.1	1.2
10.00	*	1.0	1.0	1.5	0.9	1.4	1.0	1.8	1.6	1.7
12.00	*	2.5	2.6	2.3	1.7	1.5	1.7	2.9	3.2	3.3
14.00	*	2.5	2.6	3.0	2.7	2.4	2.8	4.1	3.2	3.3
16.00	*	4.4	4.5	4.0	3.6	3.0	3.7	5.2	5.0	5.1
18.00	*	5.2	5.4	5.0	4.8	5.5	5.0	6.4	5.9	6.0
20.00	*	6.8	6.9	5.5	5.2	5.5	6.3	7.8	7.4	7.4
22.00	*	7.5	7.7	8.0	8.0	8.9	8.1	9.1	8.3	8.3
24.00	*	9.5	9.7	9.3	9.0	10.1	9.2	10.2	10.3	10.3
26.00	*	10.5	10.7	11.4	11.2	13.2	11.3	11.8	11.4	11.4
28.00	*	13.3	13.5	14.3	13.8	13.9	13.9	14.7	14.3	14.2
30.00	*	15.1	15.4	16.7	15.8	16.0	15.9	16.2	16.3	16.2
32.00	*	19.2	19.4	19.1	19.1	17.9	18.2	19.3	20.3	20.2
34.00	*	20.1	20.3	21.4	21.0	20.1	21.0	21.9	21.2	21.2
36.00	*	24.5	24.6	24.5	23.4	22.6	23.5	25.4	25.4	25.5
38.00	*	26.5	26.6	26.9	25.3	25.6	26.4	28.1	27.5	27.6
40.00	*	30.1	30.1	29.8	28.9	28.6	29.0	31.5	31.1	31.3
42.00	*	31.9	31.8	33.0	32.8	34.4	32.9	34.9	32.8	33.1
44.00	*	35.5	35.5	35.6	34.8	36.9	34.9	37.7	35.7	37.0
46.00	*	37.9	38.0	39.0	39.4	42.8	39.5	41.0	39.3	39.6
48.00	*	41.5	41.5	43.1	42.9	44.0	43.0	44.9	43.1	43.3
50.00	*	44.2	44.4	45.7	45.2	49.1	46.3	47.3	46.1	46.1
52.00	*	48.2	48.3	49.7	49.9	51.1	50.0	51.1	50.0	49.9
54.00	*	50.4	50.5	52.5	53.5	55.2	53.6	53.7	52.2	52.0
56.00	*	54.5	54.7	56.9	57.2	57.4	57.2	57.9	55.1	55.9
58.00	*	57.5	57.6	59.1	59.8	61.5	59.8	60.1	58.8	58.5
60.00	*	60.9	60.8	62.5	62.9	64.1	62.8	63.4	61.8	61.6
62.00	*	62.9	62.8	64.7	65.0	67.5	65.9	65.7	63.7	63.6
64.00	*	65.3	65.2	67.2	68.0	70.0	67.8	68.2	66.8	66.8
66.00	*	68.1	67.9	69.6	71.1	73.2	70.9	70.5	68.6	68.7
68.00	*	70.9	70.6	71.9	72.7	74.5	72.6	72.5	71.1	71.4
70.00	*	72.3	72.0	73.8	75.0	76.9	74.9	74.2	72.5	72.7
72.00	*	74.7	74.5	75.7	75.4	78.2	76.4	76.0	74.8	75.0
74.00	*	75.3	75.7	77.4	78.2	79.6	78.2	77.4	75.9	76.0
76.00	*	77.2	77.8	79.2	79.4	80.3	79.5	78.9	77.9	78.0
78.00	*	79.3	79.1	80.0	80.4	81.3	80.5	79.7	79.0	79.0
80.00	*	80.4	80.5	81.3	81.3	81.8	81.4	81.0	80.5	80.4

Table A21

A70

ENCIRCLED ENERGY

Cube #2

CIRCLE

RADIUS

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

(MT- CENTER (MICRONS):

CPONS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 10.13 -10.13 0.0 0.0 0.0 -10.13 10.13 10.13

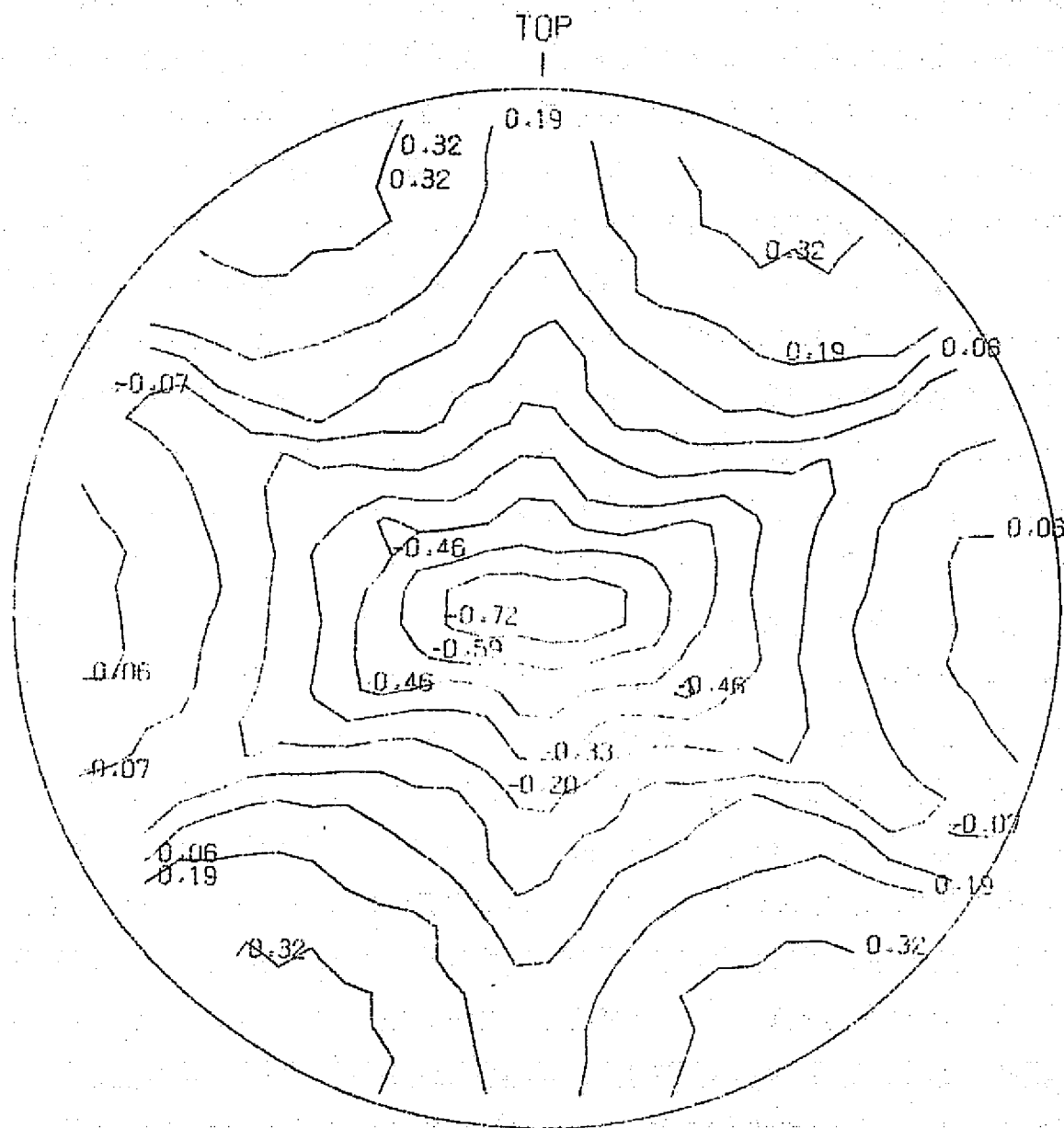
5.00	*	0.1	0.2	0.5	3.2	0.5	0.2	0.5	0.4	0.4
10.00	*	1.0	1.0	1.5	3.9	1.4	1.0	1.8	1.6	1.7
15.00	*	3.6	3.8	3.8	3.2	3.8	3.3	4.9	4.3	4.3
20.00	*	6.8	6.9	6.5	5.2	5.5	6.3	7.8	7.4	7.4
25.00	*	10.2	10.4	10.9	10.9	11.6	11.0	11.4	11.1	11.0
30.00	*	15.1	15.4	16.2	15.8	16.6	15.9	16.2	16.3	16.2
35.00	*	22.7	22.9	23.0	21.8	21.9	21.9	23.5	23.7	23.6
40.00	*	30.1	30.1	29.8	28.9	28.6	29.0	31.5	31.1	31.3
45.00	*	36.8	36.8	37.5	37.9	40.7	38.0	39.5	38.1	38.5
50.00	*	44.2	44.4	45.7	45.2	49.1	46.3	47.3	46.1	46.1
55.00	*	53.1	53.2	55.2	55.5	56.9	55.5	56.3	54.7	54.5
60.00	*	63.8	63.8	62.5	62.9	64.1	62.8	63.4	61.8	61.6
65.00	*	67.2	67.0	68.7	69.8	72.0	69.7	69.6	67.6	67.8
70.00	*	72.3	72.0	73.8	75.0	76.9	74.9	74.2	72.5	72.7
75.00	*	76.9	76.9	78.4	78.8	80.9	78.9	78.3	77.1	77.1
80.00	*	80.4	80.5	81.3	81.3	81.8	81.4	81.0	80.5	80.4
85.00	*	82.7	82.8	83.2	83.3	83.4	83.3	83.3	82.8	82.7
90.00	*	84.4	84.5	84.6	84.8	84.9	84.8	84.9	84.6	84.5
95.00	*	85.9	85.9	86.0	86.1	86.4	86.1	86.3	86.1	86.1
100.00	*	87.2	87.1	87.3	87.4	87.7	87.4	87.4	87.2	87.2
105.00	*	88.2	88.2	88.5	88.6	88.8	88.6	88.4	88.2	88.2
110.00	*	89.2	89.2	89.4	89.5	89.7	89.5	89.2	89.1	89.1
115.00	*	90.1	90.0	90.1	90.2	90.3	90.2	90.0	90.0	90.0
120.00	*	90.7	90.7	90.7	90.8	90.8	90.8	90.8	90.7	90.7
125.00	*	91.3	91.2	91.3	91.3	91.4	91.3	91.4	91.3	91.3
130.00	*	91.8	91.8	91.9	91.9	91.9	91.9	91.9	91.8	91.9
135.00	*	92.3	92.3	92.3	92.3	92.5	92.3	92.4	92.4	92.3
140.00	*	92.7	92.7	92.8	92.9	92.9	92.9	92.9	92.8	92.8
145.00	*	93.1	93.1	93.2	93.3	93.2	93.3	93.3	93.2	93.2
150.00	*	93.5	93.5	93.5	93.6	93.7	93.7	93.6	93.6	93.6
155.00	*	93.9	93.9	93.9	94.0	94.0	94.0	93.9	93.9	93.9
160.00	*	94.2	94.3	94.2	94.2	94.2	94.3	94.3	94.3	94.3
165.00	*	94.5	94.5	94.6	94.5	94.5	94.6	94.6	94.6	94.6
170.00	*	94.8	94.8	94.9	94.9	94.9	94.9	94.9	94.8	94.8
175.00	*	95.1	95.1	95.1	95.1	95.1	95.1	95.2	95.1	95.1
180.00	*	95.4	95.4	95.4	95.4	95.5	95.4	95.5	95.4	95.4
184.99	*	95.7	95.7	95.6	95.7	95.7	95.7	95.7	95.7	95.7
189.99	*	95.9	95.9	95.9	95.9	96.0	96.0	96.0	96.0	96.0
194.99	*	96.1	96.1	96.1	96.2	96.2	96.2	96.2	96.2	96.2
199.99	*	96.4	96.4	96.4	96.4	96.4	96.4	96.4	96.5	96.5

Case #3

~~MAP IN UNITS OF 0.01 WAVES~~[illegible]

Figure A50

Wavefront Plot - Q Polarization
Cube #3

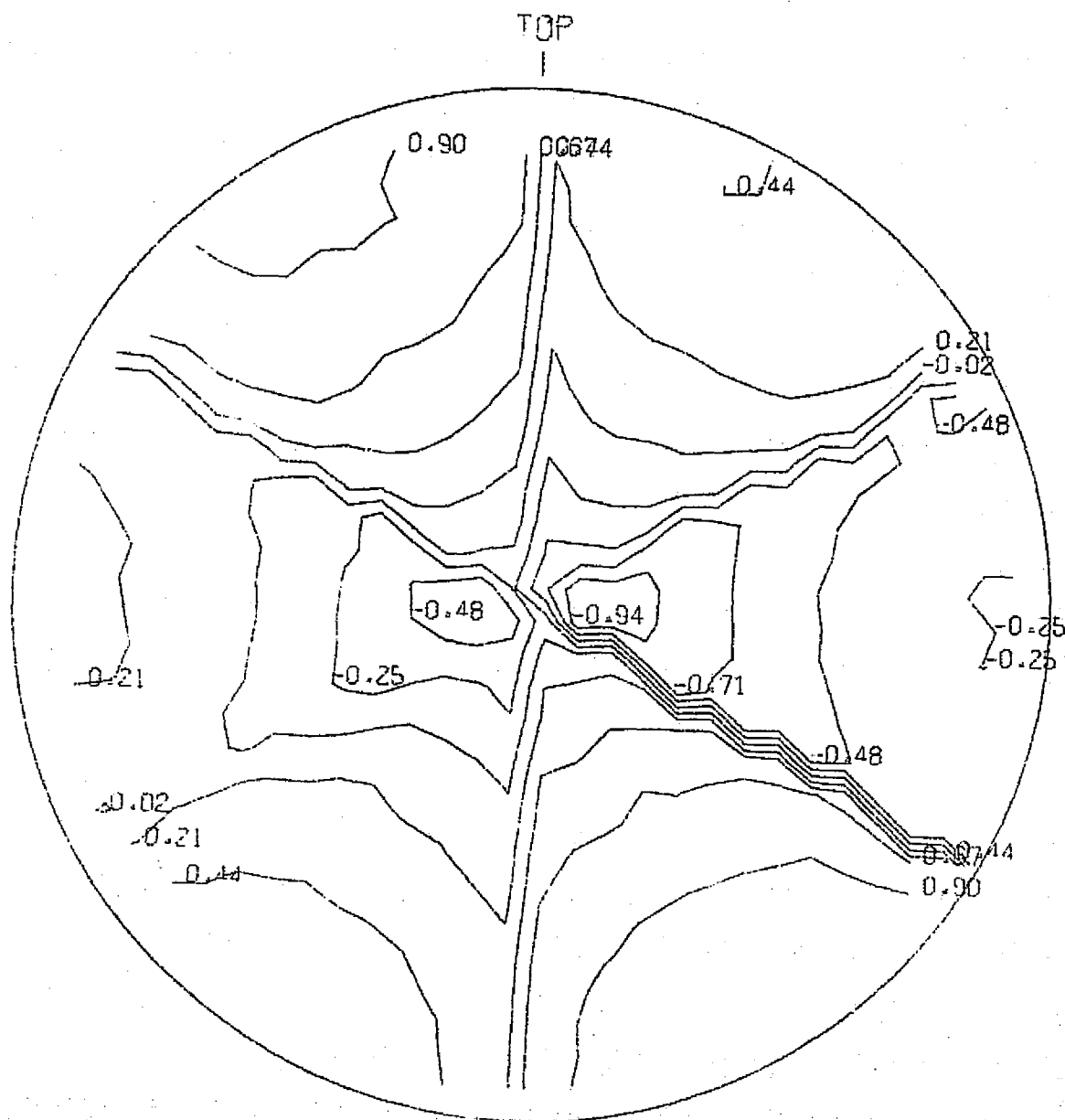


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Figure A52

Wavefront Plot - P Polarization

Cube #3



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Figure A54
Point Spread Function
Cube #3

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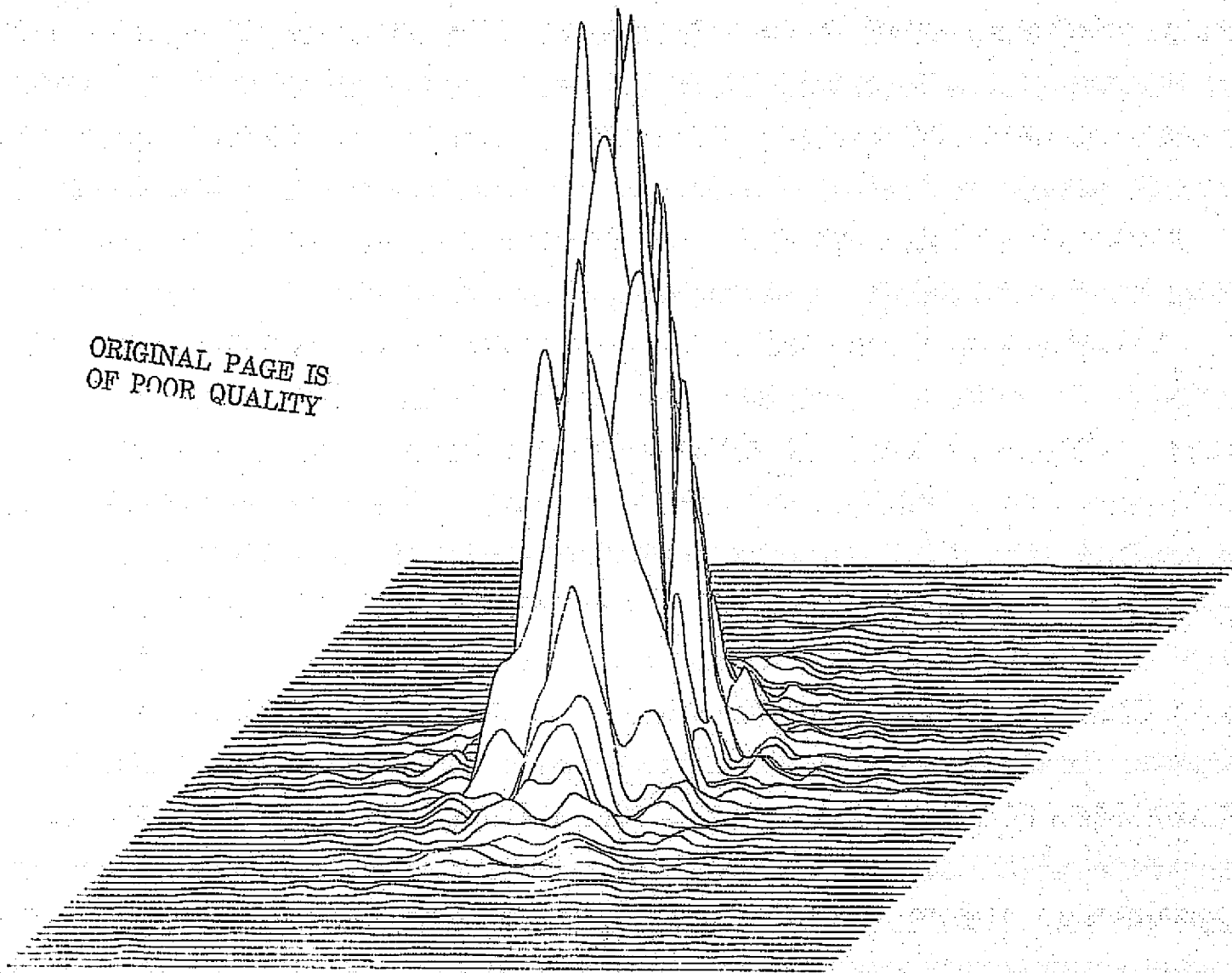
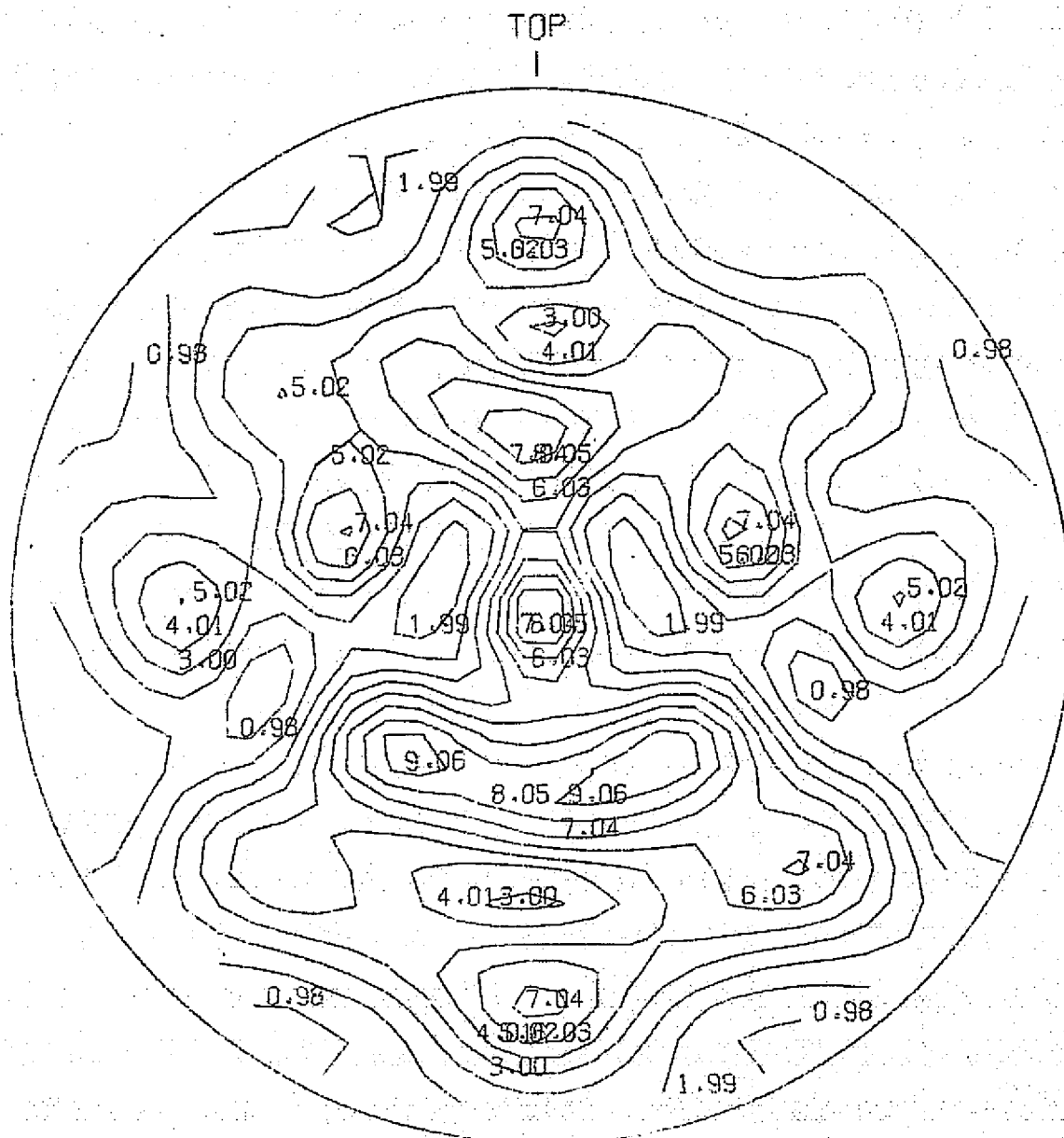


Figure A55

Intensity Distribution - Central 129 Microradians
Cube #3



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OF POOR QUALITY

Figure A56

Encircled Energy

Vs

Field Angle

Cube #3

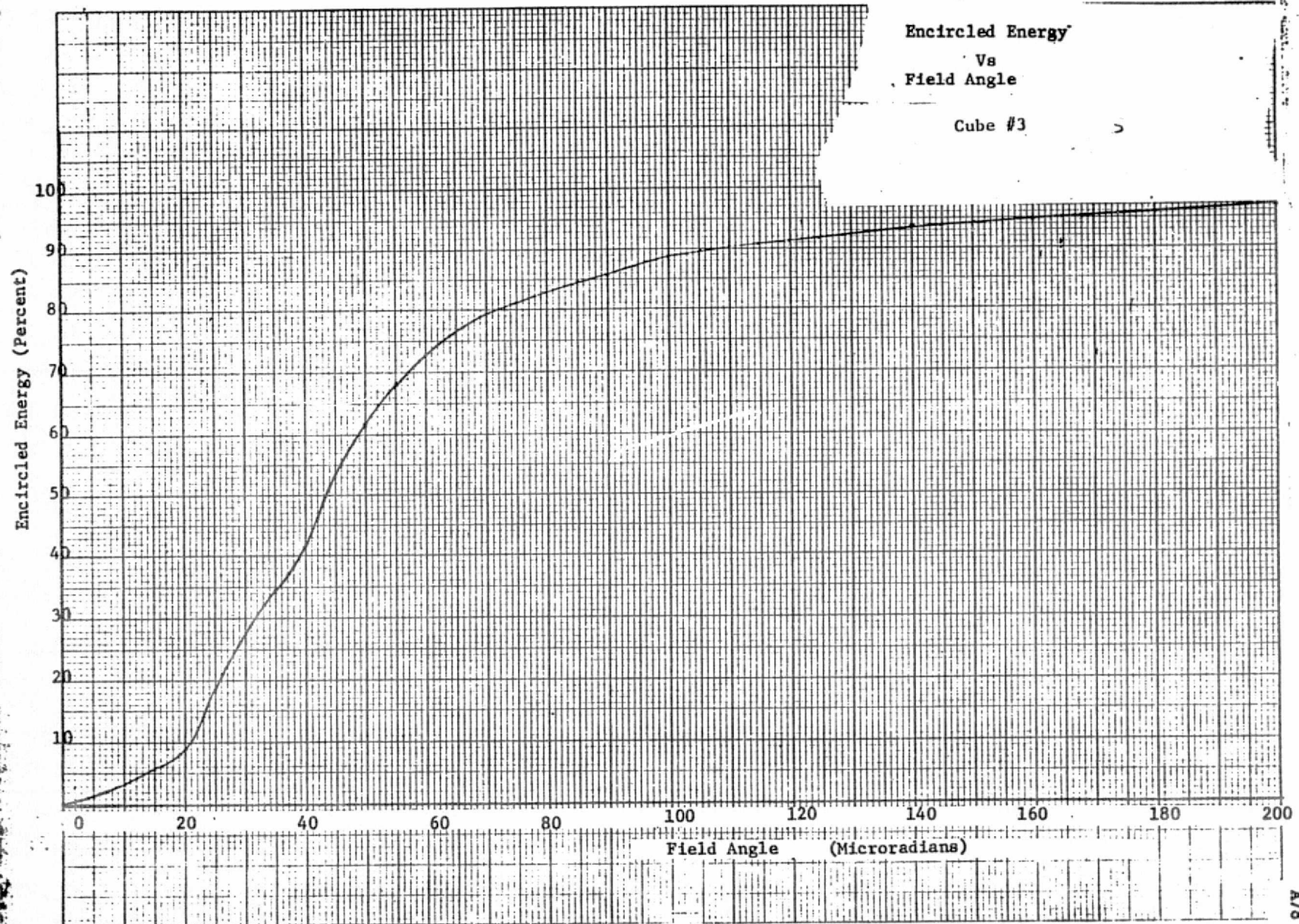


Table A22

A79

ENCIRCLED ENERGY

Cube #3

C7251-5

RADIUS

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

[MT-
CRONS)

* CENTER (MICRONS):

* X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 10.13 0.0 0.0 0.0 0.0 0.0 10.13 -10.13

2.00	*	0.0	0.0	0.2	0.0	0.3	0.0	0.2	0.0	0.0
4.00	*	0.2	0.2	0.3	0.1	0.3	0.1	0.3	0.6	0.7
6.00	*	0.2	0.2	1.9	0.5	1.9	0.5	1.1	0.6	0.7
8.00	*	1.0	1.0	1.9	1.2	1.9	1.2	2.2	1.9	2.0
10.00	*	1.6	1.5	2.4	1.5	3.2	1.6	3.0	2.7	2.8
12.00	*	4.1	4.0	3.0	3.0	3.6	3.0	4.9	5.5	5.7
14.00	*	4.1	4.0	5.0	4.8	4.8	4.9	7.0	5.5	5.7
16.00	*	7.4	7.2	6.7	6.4	5.6	6.4	3.8	8.6	8.9
18.00	*	0.7	0.6	8.1	8.4	8.9	8.5	10.8	10.1	10.4
20.00	*	11.3	11.0	10.5	10.7	8.9	10.9	13.1	12.3	12.8
22.00	*	12.5	12.3	12.3	13.7	13.9	13.7	15.3	13.7	14.1
24.00	*	15.5	15.2	14.6	15.1	16.3	15.1	16.8	16.4	17.0
26.00	*	16.9	16.6	17.9	19.5	21.3	19.5	19.3	17.9	18.6
28.00	*	20.4	20.1	21.8	22.0	22.7	22.1	22.9	21.2	22.0
30.00	*	23.0	22.7	24.8	24.9	27.2	25.0	25.0	23.9	24.7
32.00	*	28.1	27.8	28.4	27.8	29.5	29.0	28.6	28.8	29.4
34.00	*	29.2	28.9	31.8	31.5	32.1	31.8	31.8	29.9	30.6
36.00	*	34.7	34.5	35.7	34.8	35.4	35.1	36.1	35.2	35.7
38.00	*	37.2	37.0	38.5	38.1	39.5	38.4	39.0	37.7	38.2
40.00	*	41.3	41.2	42.0	41.5	41.5	41.7	43.1	42.0	42.2
42.00	*	43.4	43.3	45.3	45.7	46.9	45.8	46.8	44.2	44.4
44.00	*	47.3	47.3	47.7	47.6	49.7	47.7	49.7	48.1	48.2
46.00	*	49.8	49.8	51.1	52.1	55.5	52.1	53.1	50.9	51.0
48.00	*	52.0	52.0	54.6	55.3	56.6	55.2	56.6	54.2	54.2
50.00	*	55.4	55.5	57.0	58.2	61.7	59.1	58.6	56.9	56.9
52.00	*	58.6	58.6	60.3	61.2	63.6	61.1	61.8	59.9	59.9
54.00	*	60.4	60.5	63.1	64.1	66.7	64.9	63.8	61.8	61.8
56.00	*	63.8	63.9	66.6	67.0	68.3	67.0	67.0	64.9	64.8
58.00	*	66.2	66.3	68.1	68.8	70.8	69.8	68.4	67.0	67.0
60.00	*	68.7	68.8	70.8	71.2	72.3	71.2	71.0	69.3	69.3
62.00	*	70.4	70.5	72.2	72.9	74.0	73.0	72.4	70.9	70.8
64.00	*	72.9	73.1	73.8	74.2	75.3	74.3	74.3	73.3	73.1
66.00	*	74.3	74.5	75.2	75.9	77.0	76.0	75.8	74.6	74.6
68.00	*	75.9	76.2	76.7	76.9	77.7	77.1	77.2	76.4	76.3
70.00	*	76.9	77.1	77.8	78.2	79.1	78.3	78.3	77.3	77.3
72.00	*	78.4	78.6	79.0	79.0	80.0	79.1	79.4	78.8	78.7
74.00	*	79.1	79.2	80.0	80.2	81.0	80.3	80.3	79.5	79.4
76.00	*	80.3	80.5	81.1	81.0	81.6	81.1	81.2	80.6	80.6
78.00	*	81.2	81.3	81.7	81.8	82.4	81.9	81.7	81.4	81.4
80.00	*	82.1	82.2	82.7	82.6	82.9	82.6	82.6	82.3	82.3

Table A23

ABO

ENCIRCLED ENERGY

Cube #3

CIRCLE

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

RADIUS

(MIL- CENTER (MICRONS):

POINTS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13

5.00	*	0.2	0.2	0.8	0.4	1.2	0.4	0.9	0.6	0.7
10.00	*	1.6	1.5	2.4	1.5	3.2	1.6	3.0	2.7	2.8
15.00	*	6.1	5.6	6.3	5.6	5.6	5.7	8.2	7.3	7.6
20.00	*	11.3	11.0	10.5	10.7	8.9	10.8	13.1	12.3	12.8
25.00	*	16.4	16.1	17.1	19.1	18.3	18.1	18.9	17.4	18.0
30.00	*	23.0	22.7	24.8	24.9	27.2	25.0	25.0	23.9	24.7
35.00	*	32.6	32.4	33.7	32.7	34.6	32.9	33.6	33.0	33.5
40.00	*	41.3	41.2	42.0	41.5	41.5	41.7	43.1	42.0	42.2
45.00	*	48.6	48.6	48.7	50.6	53.2	50.6	51.6	49.7	49.8
50.00	*	55.4	55.5	57.0	58.2	61.7	58.1	58.6	56.9	56.9
55.00	*	62.6	62.7	65.0	65.7	68.1	65.6	65.7	63.7	63.7
60.00	*	68.7	68.8	70.8	71.2	72.3	71.2	71.0	69.3	69.3
65.00	*	73.5	73.7	74.8	75.3	76.3	75.4	75.2	73.9	73.8
70.00	*	76.9	77.1	77.8	78.2	79.1	78.3	78.3	77.3	77.3
75.00	*	78.8	80.0	80.5	80.6	81.4	80.6	80.9	80.2	80.2
80.00	*	82.1	82.2	82.7	82.6	82.9	82.6	82.6	82.3	82.3
85.00	*	83.9	83.9	84.4	84.3	84.4	84.4	84.2	83.9	83.9
90.00	*	85.4	85.4	85.6	85.7	85.8	85.8	85.6	85.4	85.4
95.00	*	86.7	86.8	86.8	87.0	87.1	87.0	86.9	86.8	86.8
100.00	*	87.8	87.8	87.9	88.1	88.4	88.1	88.1	87.9	87.9
105.00	*	88.8	88.8	89.0	89.1	89.3	89.1	89.1	88.9	88.8
110.00	*	89.7	89.8	89.9	89.9	90.1	89.9	89.9	89.7	89.7
115.00	*	90.6	90.6	90.6	90.6	90.7	90.6	90.5	90.5	90.5
120.00	*	91.2	91.2	91.3	91.2	91.2	91.2	91.2	91.2	91.2
125.00	*	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.8	91.7
130.00	*	92.3	92.3	92.3	92.4	92.5	92.4	92.4	92.3	92.3
135.00	*	92.8	92.8	92.8	92.9	93.0	92.9	92.8	92.8	92.8
140.00	*	93.2	93.2	93.3	93.4	93.4	93.4	93.4	93.3	93.3
145.00	*	93.6	93.6	93.6	93.8	93.8	93.8	93.8	93.7	93.7
150.00	*	94.0	94.0	94.0	94.1	94.1	94.1	94.2	94.1	94.1
155.00	*	94.3	94.3	94.4	94.4	94.4	94.4	94.5	94.4	94.4
160.00	*	94.7	94.7	94.7	94.7	94.7	94.7	94.7	94.7	94.8
165.00	*	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.1	95.0
170.00	*	95.3	95.2	95.3	95.3	95.3	95.3	95.4	95.3	95.3
175.00	*	95.5	95.5	95.5	95.6	95.6	95.6	95.6	95.6	95.6
180.00	*	95.8	95.8	95.8	95.9	96.0	95.9	95.9	95.9	95.9
184.00	*	96.1	96.1	96.0	96.1	96.1	96.1	96.1	96.1	96.1
189.00	*	96.3	96.3	96.3	96.4	96.4	96.4	96.4	96.4	96.4
194.00	*	96.5	96.5	96.5	96.6	96.6	96.5	96.6	96.6	96.6
199.00	*	96.7	96.7	96.7	96.8	96.8	96.7	96.8	96.8	96.8

ORIGINAL PAGE IS
OF POOR QUALITY

MAP IN UNITS OF 0.01 HAYES

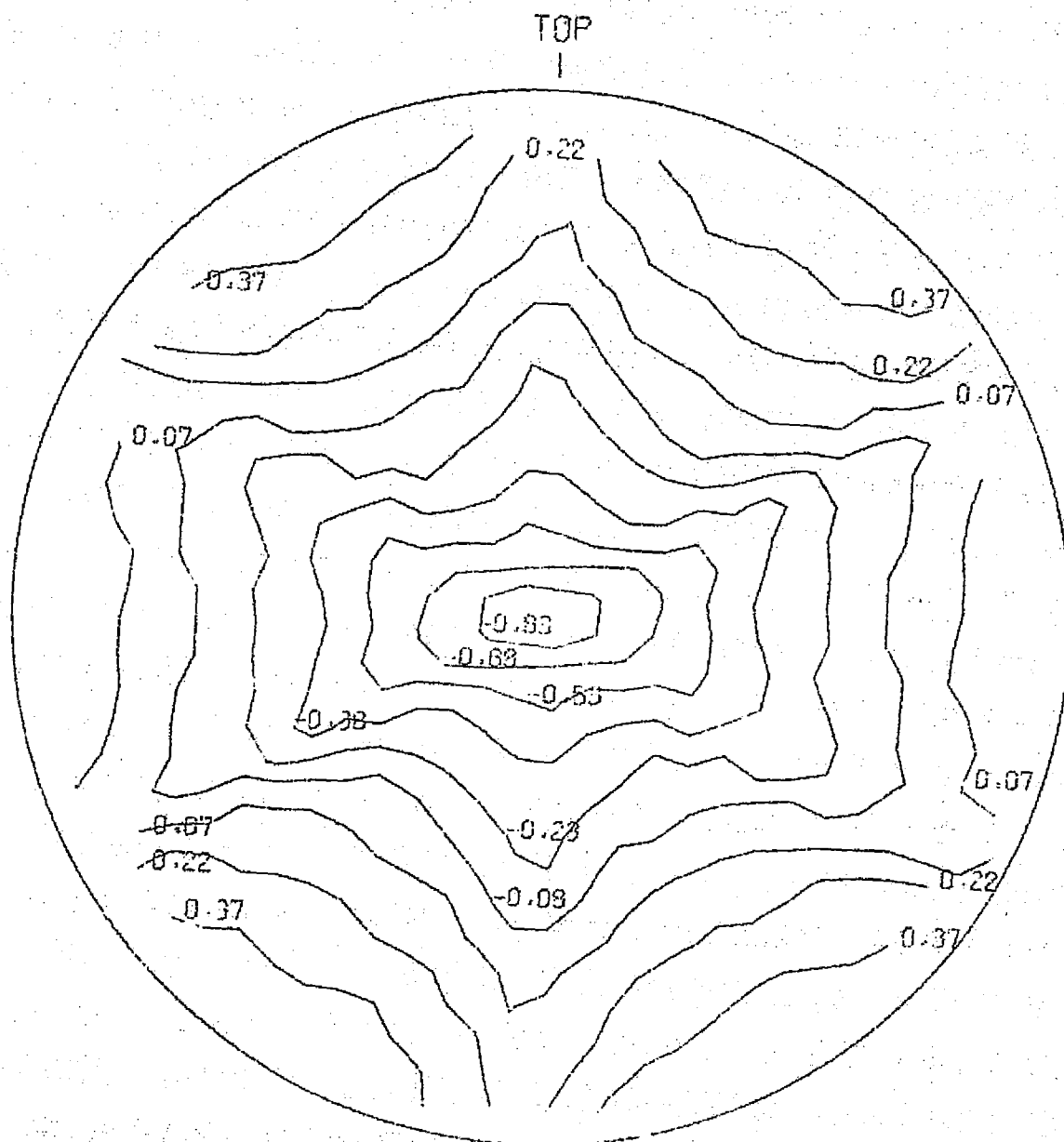
46	43	39	31	19	18	26	33	41	45																				
49	48	47	42	39	34	24	12	13	25	34	39	42	46	48	48														
50	48	46	41	36	34	27	16	11	9	23	27	34	39	41	45	44	45												
46	47	45	41	36	34	28	22	14	9	6	17	22	32	37	39	40	43	45	46										
43	40	40	40	35	32	27	24	17	11	3	3	13	20	26	28	32	32	37	41	42	42								
38	38	35	33	30	26	24	21	13	8	0	-4	-4	4	11	16	21	27	30	32	37	37	39	36						
28	35	33	29	27	25	20	20	13	9	4	-6	-14	-16	-1	8	12	17	22	26	26	29	32	30	32	19				
15	9	22	24	25	23	17	15	13	7	4	0	14	-22	-21	-10	2	5	9	14	16	19	19	24	26	17	5	5		
6	2	1	7	7	7	6	5	2	-3	-7	-9	-16	-26	-24	-17	-8	1	2	8	12	13	15	7	6	3	0	3		
5	4	-2	0	-7	-9	1	-1	-6	-8	-12	-18	-24	-33	-33	-23	-16	-6	-4	0	3	2	3	7	11	-6	1	7		
16	13	7	-4	-9	-17	-22	-22	-23	-15	-17	-17	-25	-29	-35	-35	-29	-24	-18	-9	-16	-21	-25	-18	-15	-9	-3	5	12	10
16	13	3	0	-8	-15	-25	-33	-29	-26	-35	-26	-32	-37	-44	-44	-37	-33	-31	-34	-33	-43	-33	-22	-17	-9	0	7	11	12
16	13	6	2	-9	-16	-22	-27	-38	-47	-51	-43	-44	-55	-52	-42	-39	-40	-51	-47	-40	-28	-21	-16	-8	-3	-8	-14	-18	
17	12	9	5	-9	-17	-19	-26	-41	-48	-56	-57	-64	-63	-65	-67	-69	-68	-66	-58	-50	-37	-28	-22	-14	-3	3	7	14	19
20	12	10	2	-3	-14	-22	-29	-36	-45	-61	-65	-76	-84	-95	-89	-86	-72	-68	-56	-45	-34	-27	-21	-12	-4	0	8	15	21
21	15	8	0	-4	-12	-21	-27	-34	-45	-56	-68	-72	-86	-89	-95	-84	-76	-65	-61	-45	-36	-29	-22	-14	-3	2	10	12	20
19	14	7	3	-3	-14	-22	-28	-37	-50	-58	-66	-68	-69	-67	-65	-63	-64	-57	-56	-48	-41	-26	-19	-17	-9	5	9	12	17
18	14	8	3	-8	-16	-21	-28	-40	-47	-51	-40	-39	-42	-52	-55	-44	-44	-45	-51	-47	-38	-27	-22	-16	-9	2	6	13	16
12	11	7	0	-9	-17	-22	-33	-43	-33	-34	-31	-33	-37	-44	-44	-37	-32	-26	-35	-26	-29	-33	-25	-15	-8	0	3	13	16
14	12	5	-3	-9	-15	-18	-25	-21	-16	-9	-18	-24	-29	-35	-35	-29	-25	-17	-17	-15	-23	-22	-22	-17	-9	-4	7	13	16
7	1	-6	-11	-7	3	2	3	0	-4	-6	-16	-23	-33	-33	-24	-18	-12	-8	-6	-1	1	-9	-7	0	-2	4	5		
3	0	3	6	7	15	13	12	8	2	1	8	17	24	26	16	9	7	3	2	5	6	7	7	7	1	2	6		
5	5	17	26	24	19																								

20768

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Figure A58

Wavefront Plot ~ Q Polarization
Cube #4



Cube #4

MAP IN UNITS OF 0.01 WAVES

105 101 97 89 78 26 35 41 50 53

108 106 105 101 97 92 83 71 21 33 42 48 51 54 56 56

108	106	104	99	95	93	85	75	69	18	31	36	43	48	50	53	53	54
-----	-----	-----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

104-105-103-100-94-92-87-80-73-67-15-26-31-40-45-47-49-51-53-54

102	99	99	99	93	90	86	82	75	70	61	12	21	28	34	36	41	41	45	50	50	51
-----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

96 96 93 91 89 84 82 79 72 67 59 53 4 12 20 25 30 35 38 41 45 45 48 44

86	93	91	88	85	83	79	79	71	68	62	52	43	7	7	17	20	25	30	35	35	37	40	39	40	27		
31	68	81	83	83	82	76	74	72	66	62	59	43	36	-12	-1	10	14	17	22	25	28	27	32	34	25	14	-28

31	68	61	63	65	62	70	74	72	66	62	59	45	56	-12	-1	10	14	17	22	23	26	27	32	34	23	14	-26
22	18	17	65	65	66	64	64	60	55	50	48	41	31	-16	-9	0	10	11	17	20	21	23	15	15	-30	-34	-30

21-20-13-15-31-49-59-57-52-49-45-39-34-25-24-15-7-2-3-8-12-11-11-1-45-40-32-26

32	29	23	11	6	-1	-6	35	35	42	41	40	33	28	22	-26	-20	-16	-9	0	-7	-12	-17	-52	-49	-43	-37	-28	-21	-19
32	29	19	16	7	0	-9	-17	-13	31	23	22	26	21	13	-35	-38	-25	-23	-25	-25	-37	-67	-56	-61	-63	-36	-26	-32	-21

~~32 29 19 16 7 0 -9 -17 -13 31 23 32 26 21 13 -35 -28 -25 -23 -25 -25 -77 -67 -56 -51 -43 -34 -26 -22 -21~~
~~32 29 22 18 6 0 -6 -11 -22 -31 -35 -13 -14 -13 -3 -43 -34 -31 -32 -85 -81 -74 -62 -55 -50 -42 -30 -25 -19 -15~~

33	28	25	21	6	-1	-3	-10	-25	-32	-40	-41	-6	-5	-7	-59	-60	-60	-100	-92	-84	-71	-62	-56	-48	-37	-30	-26	-19	-14
----	----	----	----	---	----	----	-----	-----	-----	-----	-----	----	----	----	-----	-----	-----	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

36 28 26 18 12 1 -6 -13 -20 -29 -45 -49 -60 -68 -36 -81-120-106-102 -90 -79 -68 -61 -55 -46 -38 -33 -25 -18 -12

37 31 24 16 11 3 3 11 18 29 40 52 56 70 69 24 118 110 99 95 79 70 63 56 48 37 31 23 21 13
35 30 23 19 12 1 6 12 21 34 42 50 48 49 47 4 6 5 91 90 82 75 60 53 51 43 28 24 21 16

35	30	23	19	12	1	-6	-12	-21	-34	-42	-50	-48	-49	-47	4	6	5	-91	-90	-82	-75	-60	-53	-51	-43	-28	-24	-21	-16
34	30	24	19	7	0	-5	-12	-24	-31	-35	-20	-19	-22	-32	14	25	25	25	-85	-81	-72	-61	-56	-50	-43	-31	-27	-20	-17

28-27-23-19-8-1-6-17-27-13-14-11-19-17-23-25-33-37-44-35-43-63-67-59-49-42-33-30-20-17

30	28	21	12	6	0	-2	-5	0	4	10	1	-4	-9	-15	34	40	44	52	52	54	46	47	-56	-51	-43	-38	-26	-20	-17
----	----	----	----	---	---	----	----	---	---	----	---	----	----	-----	----	----	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----

23 17 9 4 12 23 22 23 19 15 13 4 -3 -12 37 45 51 57 61 64 69 71 60 63 -34 -36 -29 -28
~~19 15 19 26 27 35 33 32 28 22 21 11 2 4 43 53 60 62 66 72 76 76 77 77 77 77 32 31 27~~

19	19	19	20	21	33	33	32	28	22	21	11	2	4	43	33	60	82	68	72	18	16	11	11	11	32	31	21
21	25	37	46	44	35	33	36	34	29	25	22	9	0	47	55	71	74	78	83	85	88	93	95	95	93	80	-18

39 52 50 52 49 47 46 42 37 32 28 18 3 55 64 74 79 83 90 90 95 97 100 103 105 98

56 59 57 57 52 50 47 41 36 31 24 15 65 71 79 83 91 94 96 101 103 105 108 108
62 62 62 57 53 52 48 46 40 33 23 73 81 87 94 98 102 105 110 111 111 114

62 62 62 57 53 52 48 46 40 33 23 73 81 87 94 98 102 105 110 111 111 114
66 65 63 60 59 57 52 42 37 26 79 85 92 98 104 106 112 115 117 116

85 85 85 61 59 55 48 43 29 81 86 97 104 107 111 116 118 120

68	68	66	62	59	54	45	33	82	94	104	109	112	117	118	119
					45	62	53	44	38	80	101	100	113	117	

65 62 53 46 38 90 101 109 113 117

Figure A60

Wavefront Plot - P Polarization

Cube #4

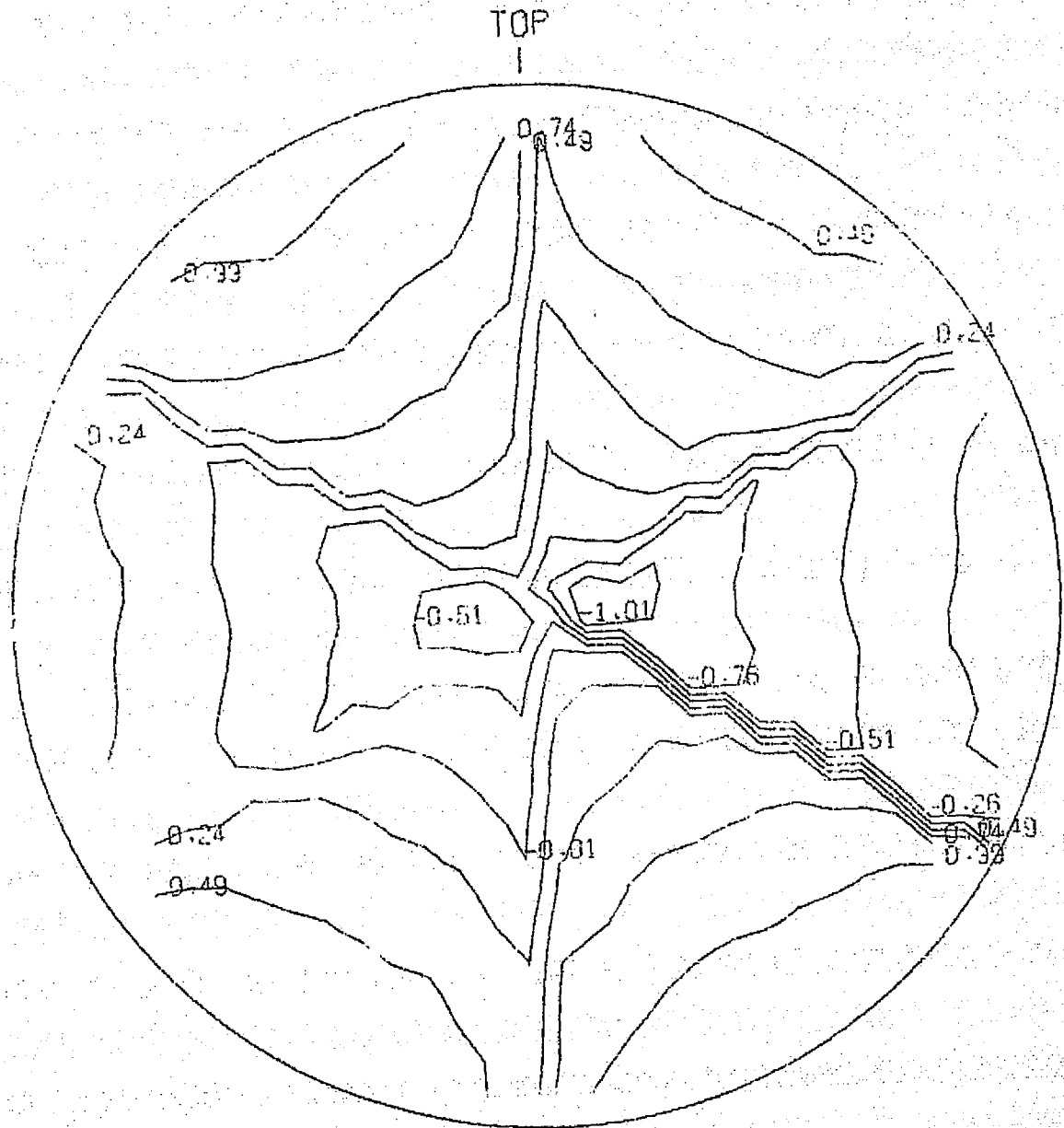


Figure A61

PRINTER MAP OF POINT SPREAD FUNCTION

Cube #4

ONE SPACE REPRESENTS 9.04 MICRONS

~~NORMALIZED SO LARGEST VALUE = 0.0203 = 100~~

TOTAL ENERGY = 0.2461000D+01

MAP REPRESENTS 0.2305069D+01 OR 93.6639 PERCENT OF TOTAL ENERGY

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Figure A62

Point Spread Function

Cube #4

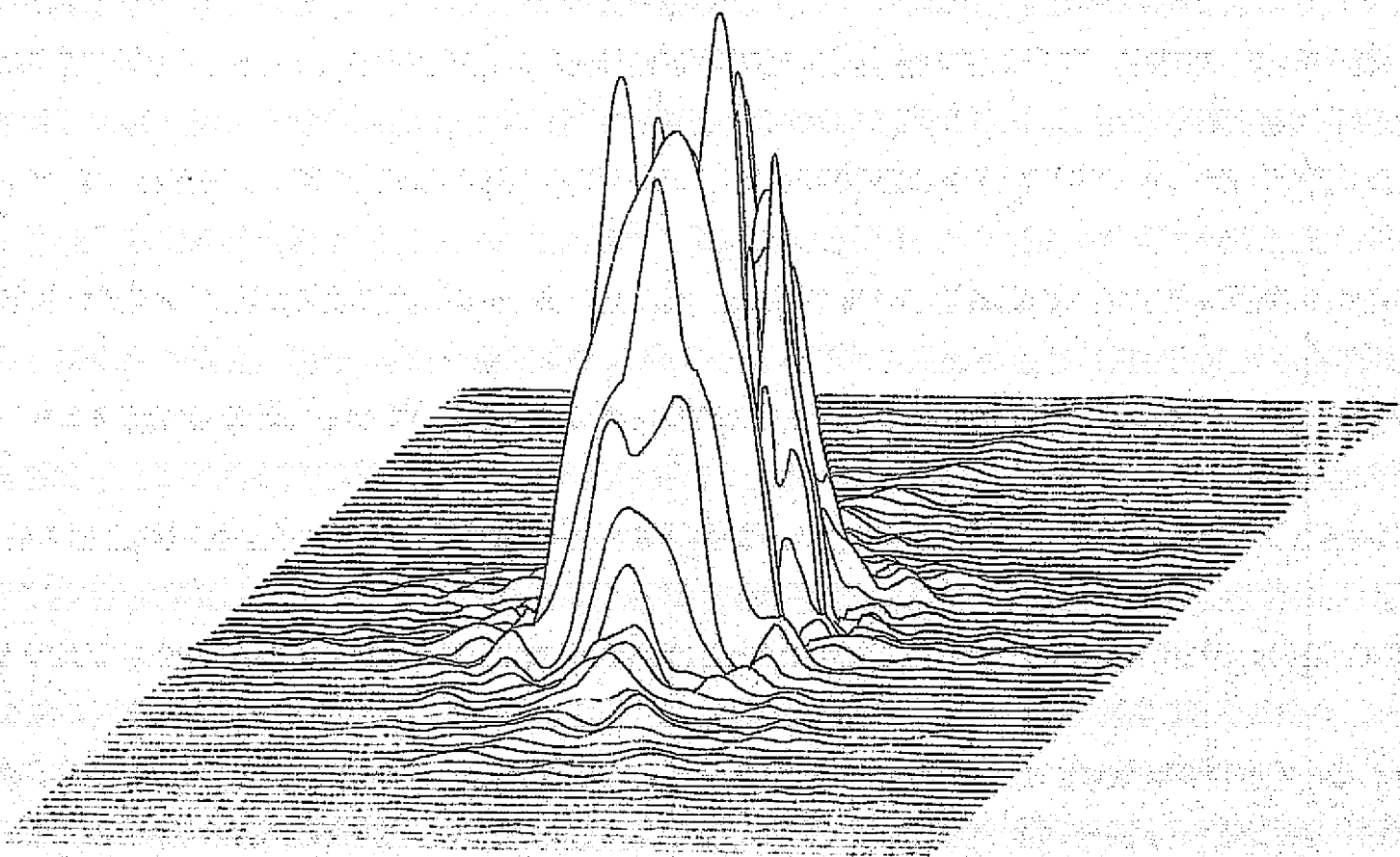


Figure A63

Intensity Distribution - Central 129 Microradians

Cube #4

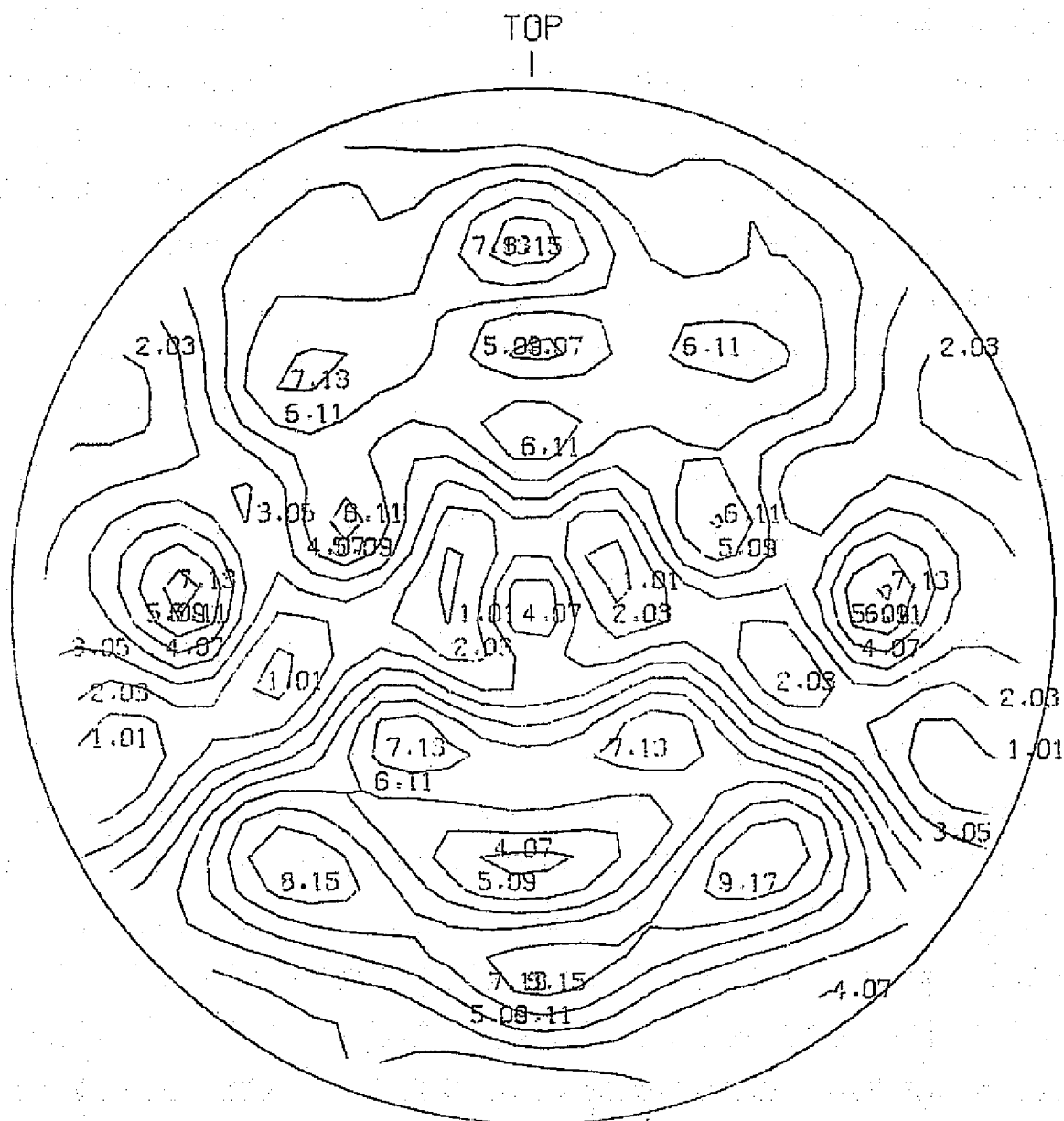


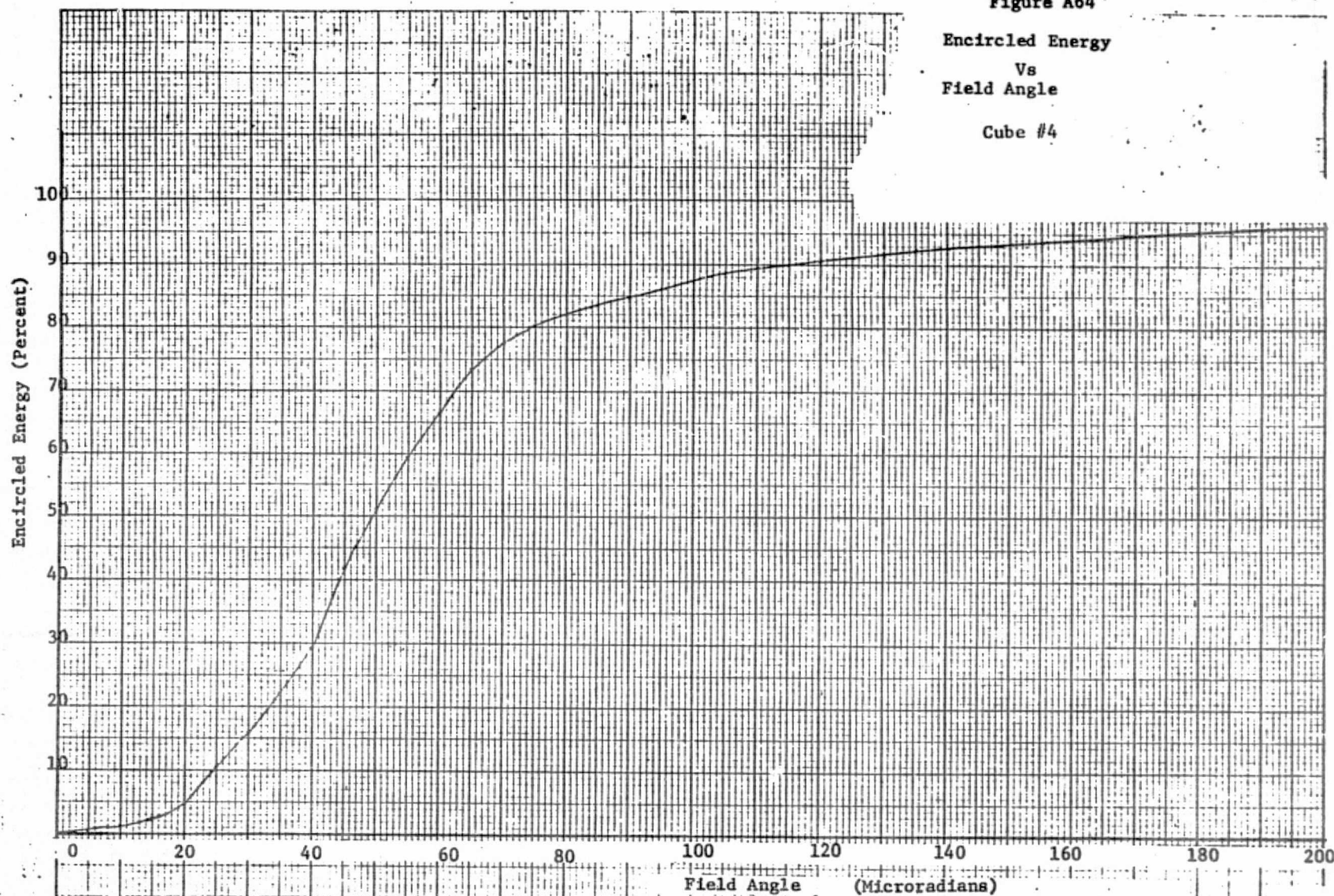
Figure A64

Encircled Energy

Vs

Field Angle

Cube #4



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Table A24

ENCIRCLED ENERGY

Cube #4

CIRCLE *

RADIUS *

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

{MI-
CROVS)

* CENTER {MICRONS}:

* X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13

2.00	*	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0
4.00	*	0.2	0.2	0.1	0.0	0.1	0.1	0.1	0.3	0.4
6.00	*	0.2	0.2	0.5	0.2	0.7	0.2	0.5	0.3	0.4
8.00	*	0.6	0.6	0.9	0.5	0.7	0.5	1.0	1.1	1.2
10.00	*	0.9	1.0	1.1	0.7	1.1	0.9	1.5	1.5	1.6
12.00	*	2.3	2.3	1.8	1.4	1.3	1.5	2.4	2.9	3.1
14.00	*	2.3	2.3	2.5	2.4	1.9	2.6	3.5	2.9	3.1
16.00	*	4.1	4.1	3.3	3.2	2.4	3.4	4.5	4.6	4.8
18.00	*	4.9	4.9	4.3	4.4	4.6	4.6	5.7	5.5	5.7
20.00	*	6.4	6.4	5.7	5.7	4.6	5.8	6.9	6.9	7.2
22.00	*	7.2	7.1	7.3	7.4	7.7	7.5	8.4	7.7	8.0
24.00	*	9.2	9.0	8.6	8.4	9.2	8.5	9.5	9.7	10.1
26.00	*	10.3	10.0	10.7	10.5	12.2	10.6	11.2	10.8	11.4
28.00	*	13.2	12.8	13.6	13.2	13.1	13.3	14.2	13.7	14.4
30.00	*	15.1	14.7	15.7	15.4	15.9	15.4	15.9	15.8	16.5
32.00	*	19.3	18.9	18.4	17.8	17.6	17.9	19.0	19.8	20.6
34.00	*	20.2	19.8	21.1	20.9	19.8	21.0	21.9	20.9	21.6
36.00	*	24.7	24.3	24.2	23.7	22.8	23.3	25.5	25.3	25.9
38.00	*	26.8	26.6	26.8	26.8	27.2	26.9	28.3	27.8	28.2
40.00	*	30.5	30.3	30.0	29.8	29.3	29.9	32.0	31.6	31.9
42.00	*	32.4	32.3	33.7	33.9	35.1	34.0	35.8	33.7	33.8
44.00	*	36.3	36.3	36.3	36.1	38.2	36.2	38.5	37.8	37.8
46.00	*	39.0	39.1	40.3	40.9	44.2	41.0	42.4	40.8	40.8
48.00	*	42.6	42.7	44.5	44.8	45.7	44.8	46.4	44.5	44.4
50.00	*	45.8	45.8	47.3	48.1	51.1	48.1	48.8	47.7	47.6
52.00	*	49.7	49.8	51.2	52.0	53.5	52.0	52.6	51.5	51.3
54.00	*	52.0	52.0	54.4	55.7	57.5	55.6	55.5	53.6	53.6
56.00	*	56.2	56.3	58.5	59.5	60.1	59.5	59.5	57.5	57.4
58.00	*	59.2	59.2	60.8	61.9	64.0	61.9	61.8	60.2	60.2
60.00	*	62.3	62.3	64.1	65.1	66.6	65.1	65.0	63.1	63.0
62.00	*	64.4	64.4	66.6	67.7	69.6	67.7	67.4	65.2	65.1
64.00	*	67.7	67.8	68.8	69.6	71.9	69.6	69.7	68.3	68.1
66.00	*	69.6	69.6	71.3	72.2	74.5	72.2	72.1	70.1	70.0
68.00	*	72.0	72.1	73.5	73.9	75.6	73.8	74.0	72.6	72.4
70.00	*	73.5	73.5	75.3	75.7	77.6	75.6	75.6	73.9	73.8
72.00	*	75.7	75.7	76.9	77.1	78.7	77.0	77.1	76.0	75.9
74.00	*	76.7	76.8	78.5	78.6	79.9	78.5	78.3	77.0	76.8
76.00	*	78.6	78.6	79.9	79.8	80.6	79.7	79.5	78.7	78.5
78.00	*	79.7	79.7	80.6	80.7	81.4	80.6	80.2	79.7	79.5
80.00	*	80.8	80.9	81.6	81.5	82.0	81.5	81.3	80.9	80.7

Table A25

ENCIRCLED ENERGY

Cube #4

CIRCLE *
 ----- * PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES
 RADIUS *
 ----- *

(MI- * CENTER (MICRONS):
 CRVS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13
 * Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13
 *

5.00	*	0.2	0.2	0.3	0.1	0.4	0.2	0.4	0.3	0.4
10.00	*	0.9	1.0	1.1	0.7	1.1	0.3	1.5	1.5	1.6
15.00	*	3.4	3.4	3.1	2.8	2.4	2.9	4.1	3.9	4.1
20.00	*	6.4	6.4	5.7	5.7	4.6	5.8	6.9	6.9	7.2
25.00	*	9.9	9.7	10.2	10.3	10.4	10.4	10.9	10.5	11.0
30.00	*	15.1	14.7	15.7	15.4	15.9	15.4	15.9	15.8	16.5
35.00	*	22.9	22.5	22.5	21.9	22.0	22.0	23.3	23.4	24.0
40.00	*	30.5	30.3	30.0	29.8	29.3	29.9	32.0	31.6	31.9
45.00	*	37.7	37.7	38.6	39.3	41.8	39.3	40.7	39.4	39.4
50.00	*	45.8	45.8	47.3	48.1	51.1	48.1	48.8	47.7	47.6
55.00	*	54.7	54.8	56.7	57.7	59.5	57.6	57.8	56.1	56.0
60.00	*	62.3	62.3	64.1	65.1	66.6	65.1	65.0	63.1	63.0
65.00	*	68.6	68.6	70.4	71.2	73.5	71.2	71.2	69.1	69.0
70.00	*	73.5	73.5	75.3	75.7	77.6	75.6	75.6	73.9	73.8
75.00	*	77.8	77.8	79.2	79.2	80.3	79.2	79.0	78.0	77.9
80.00	*	80.8	80.9	81.6	81.5	82.0	81.5	81.3	80.8	80.7
85.00	*	82.9	82.9	83.3	83.3	83.5	83.3	83.2	82.8	82.7
90.00	*	84.3	84.4	84.6	84.7	84.7	84.7	84.7	84.4	84.4
95.00	*	85.7	85.8	85.8	85.9	86.0	86.0	86.0	85.8	85.9
100.00	*	86.9	87.0	87.0	87.1	87.3	87.1	87.0	86.9	86.9
105.00	*	87.9	88.0	88.1	88.1	88.4	88.2	88.0	87.9	87.9
110.00	*	88.8	88.9	89.1	89.0	89.3	89.1	88.9	88.8	88.8
115.00	*	89.7	89.8	89.8	89.8	89.9	89.8	89.7	89.7	89.7
120.00	*	90.4	90.4	90.5	90.4	90.5	90.5	90.5	90.4	90.4
125.00	*	91.0	91.0	91.1	91.0	91.1	91.1	91.1	91.0	91.0
130.00	*	91.6	91.6	91.6	91.6	91.7	91.6	91.7	91.6	91.6
135.00	*	92.0	92.0	92.1	92.1	92.3	92.1	92.2	92.1	92.1
140.00	*	92.5	92.5	92.5	92.7	92.6	92.6	92.7	92.6	92.6
145.00	*	92.9	92.9	92.9	93.1	93.0	93.0	93.1	93.0	93.0
150.00	*	93.3	93.3	93.3	93.4	93.4	93.4	93.4	93.4	93.4
155.00	*	93.7	93.7	93.8	93.7	93.7	93.7	93.8	93.7	93.8
160.00	*	94.1	94.1	94.1	94.0	94.0	94.1	94.0	94.1	94.1
165.00	*	94.4	94.4	94.5	94.4	94.4	94.4	94.4	94.4	94.4
170.00	*	94.7	94.7	94.8	94.8	94.8	94.3	94.8	94.7	94.7
175.00	*	95.0	95.0	95.0	95.1	95.1	95.1	95.1	95.1	95.1
180.00	*	95.3	95.3	95.3	95.4	95.4	95.4	95.4	95.4	95.4
184.99	*	95.6	95.6	95.5	95.6	95.6	95.6	95.7	95.7	95.7
189.99	*	95.8	95.8	95.8	95.9	95.9	95.9	95.9	95.9	95.9
194.99	*	96.1	96.1	96.1	96.1	96.1	96.1	96.1	96.1	96.2
199.99	*	96.3	96.3	96.3	96.3	96.3	96.3	96.4	96.4	96.4

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Figure A65

Wavelength μm - 0 Polarization

Cuba #5

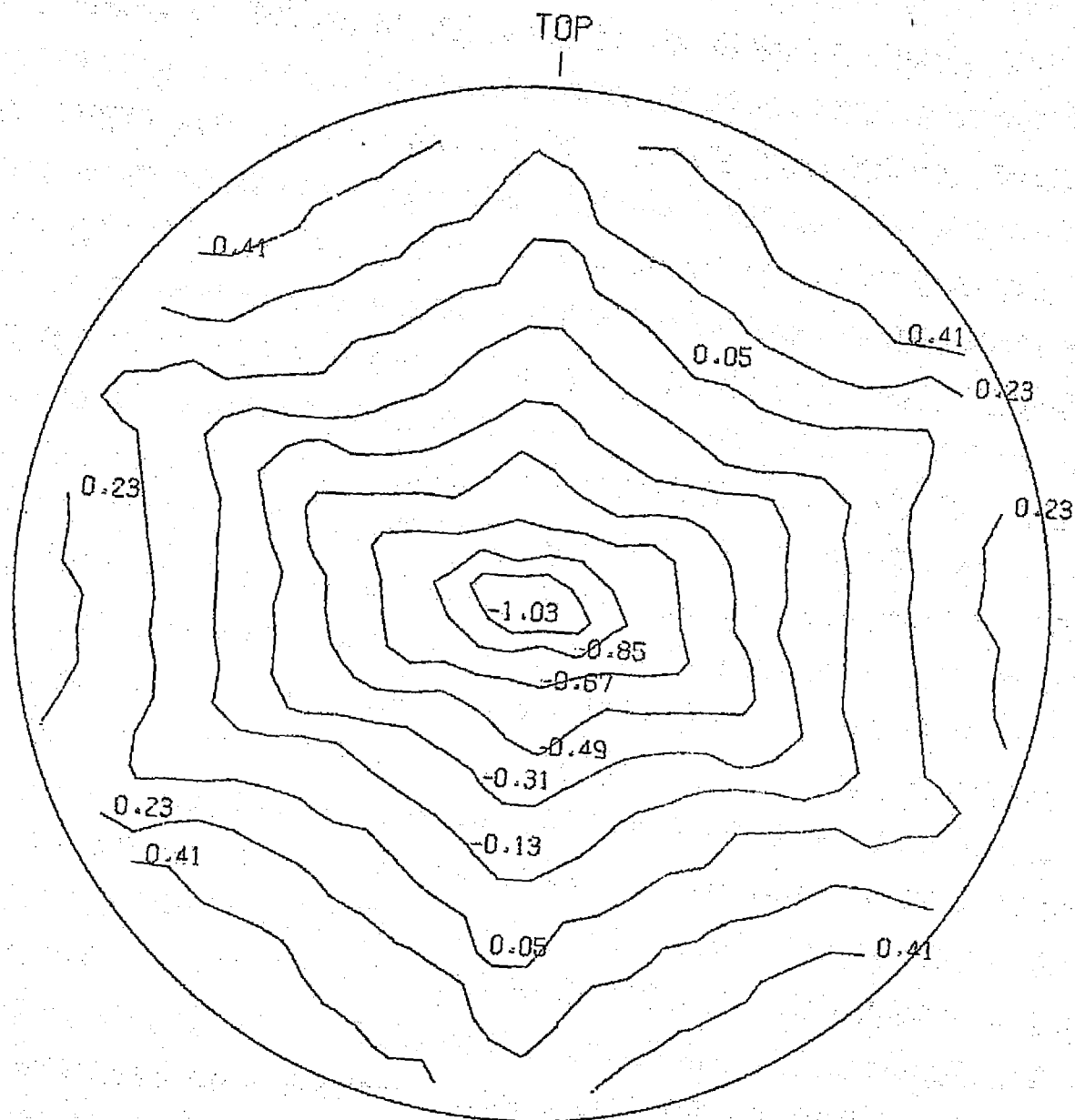
MAP IN UNITS OF 0.01 WAVES

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Figure A66

Wavefront Plot - Q Polarization
Cube #5



Cube #5

68 65 65 55 48 97 102 110 113 117

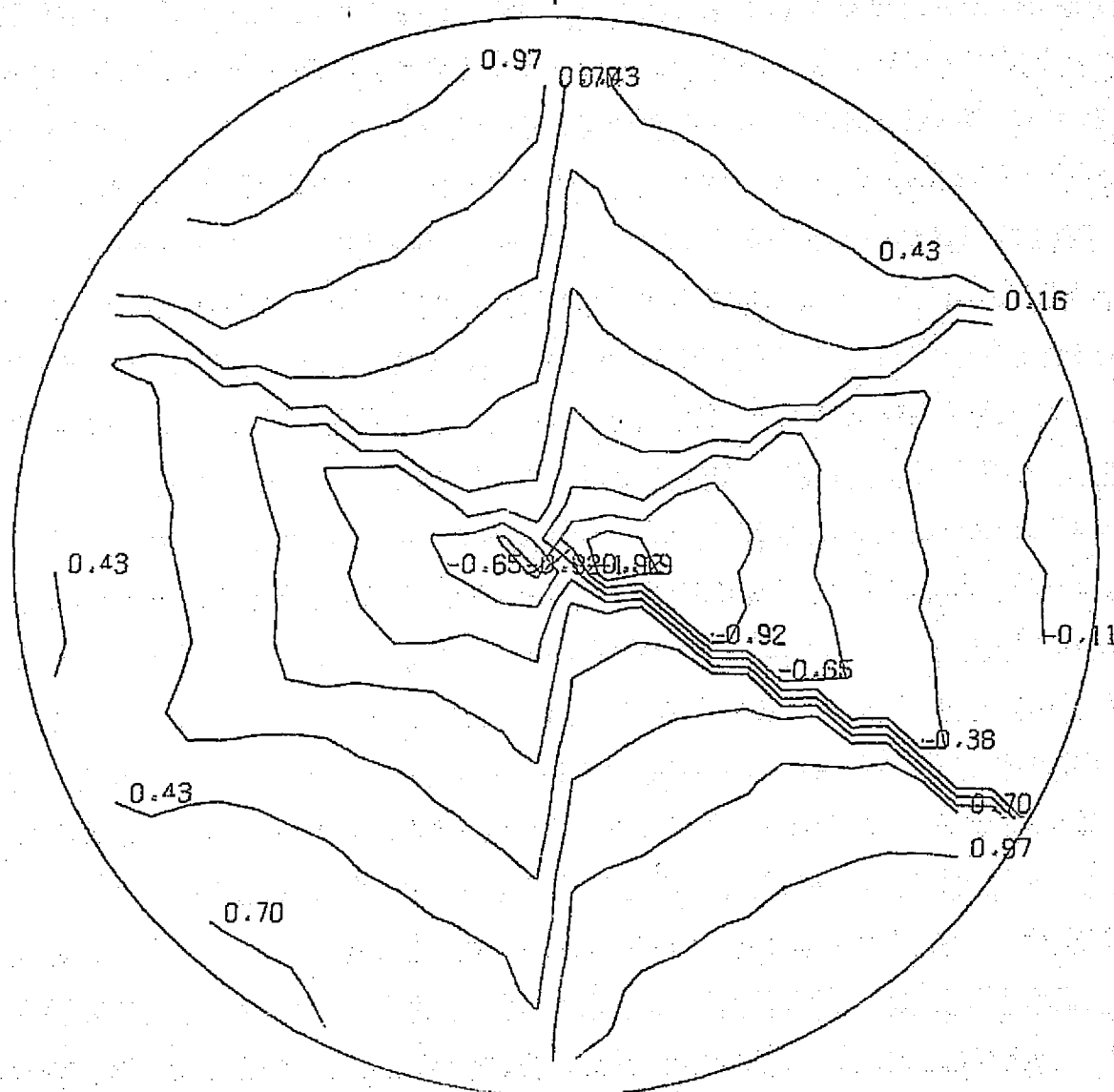
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Figure A68

Wavefront Plot - P Polarization

Cube #5

TOP



PRINTER MAP OF POINT SPREAD FUNCTION

Cube #5

(ONE SPACE REPRESENTS 8.04 MICRONS)

UNION SQUARE REPRESENTS 0.04 HICKORY
NORMALIZED SO LARGEST VALUE = 0.0182 = 100

TOTAL ENERGY = 0.2461000D+01

MAP REPRESENTS 0.2303980D+01 OR 93.6197 PERCENT OF TOTAL ENERGY

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Figure A70

Point Spread Function

Cube #5

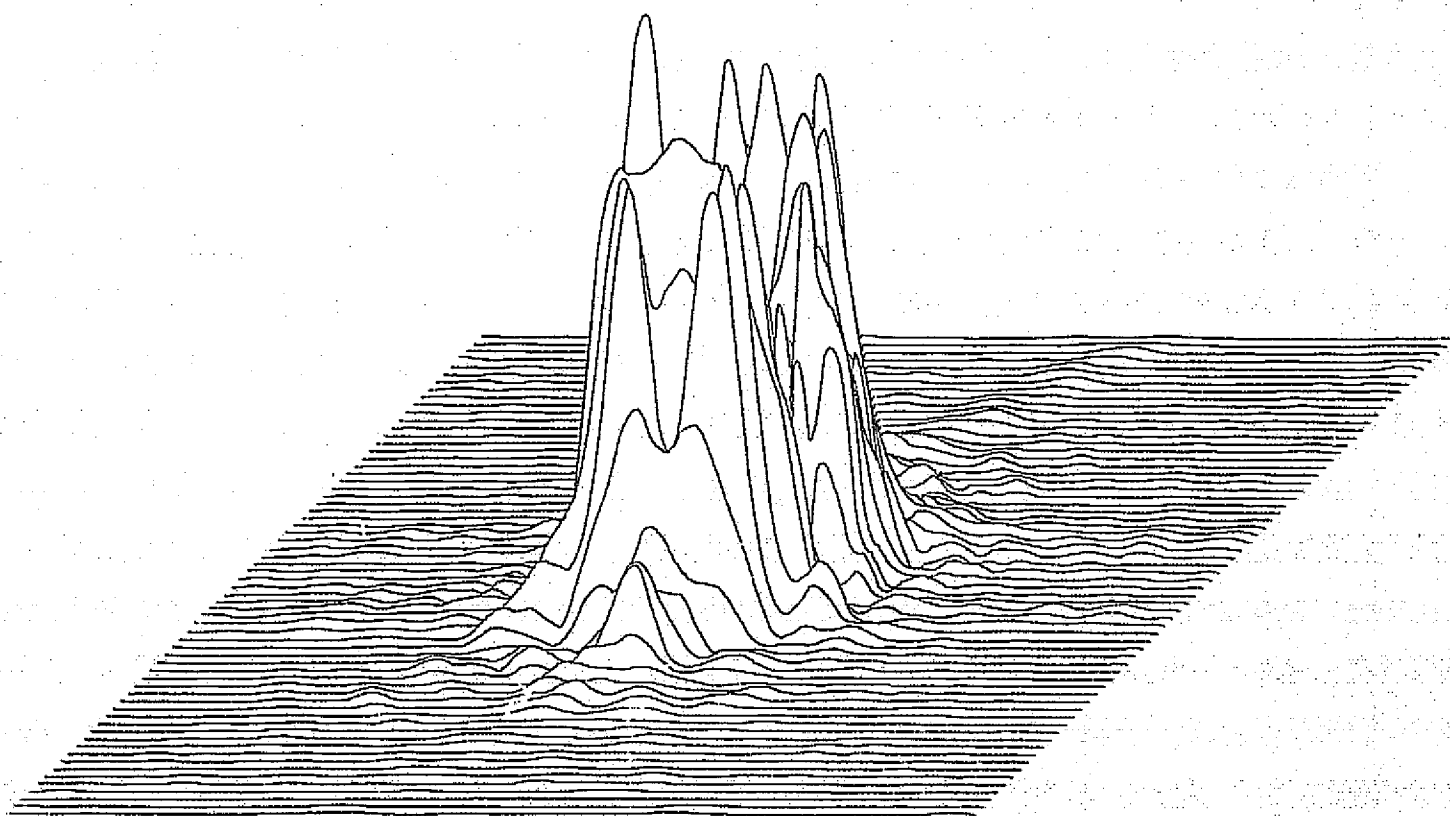
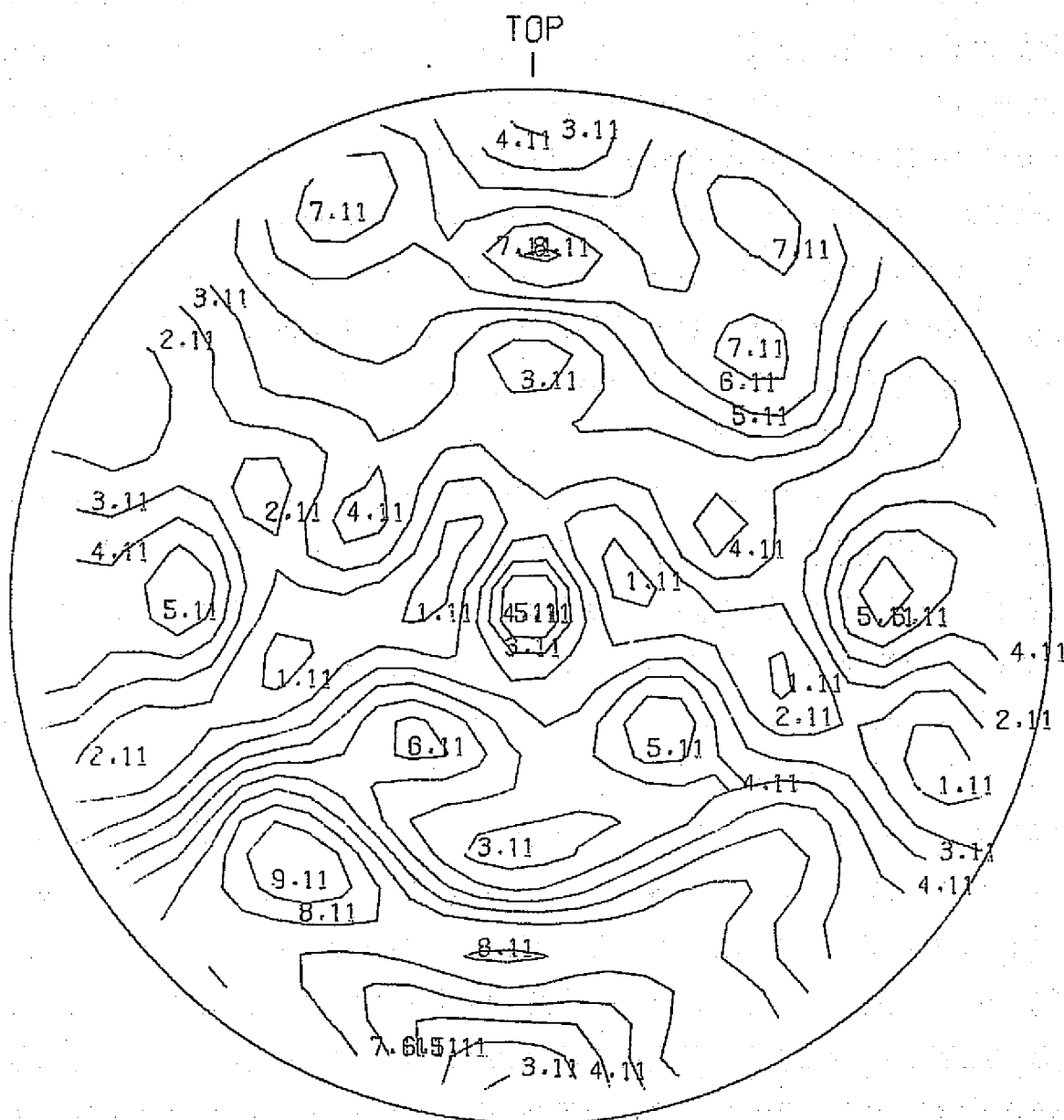


Figure A71

Intensity Distribution - Central 129 Microradians
Cube #5



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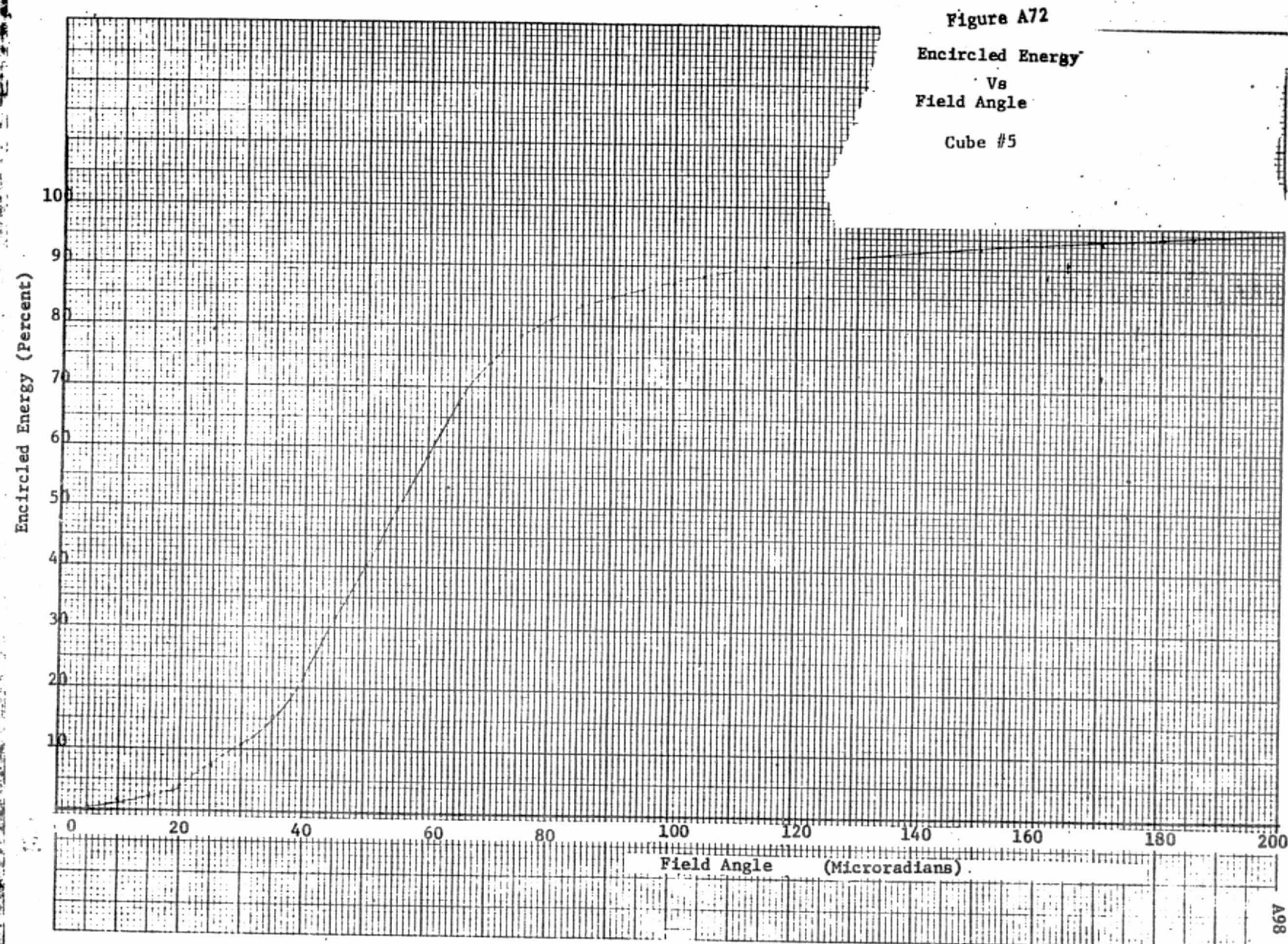


Table A26

A99

ENCIRCLED ENERGY

Cube #5

*****1.

CIRCLE *

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

RADIUS *

(MI-
CRONS)

* CENTER (MICRONS):

* X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13

2.00	*	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0
4.00	*	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.3
6.00	*	0.1	0.1	0.3	0.2	0.8	0.2	0.4	0.3	0.3
8.00	*	0.4	0.5	0.7	0.5	0.8	0.5	0.8	0.8	0.8
10.00	*	0.7	0.7	0.9	0.7	1.3	0.7	1.1	1.2	1.1
12.00	*	1.7	1.8	1.5	1.3	1.4	1.3	1.8	2.3	2.1
14.00	*	1.7	1.8	2.0	2.0	1.9	2.1	2.7	2.3	2.1
16.00	*	2.9	3.1	2.6	2.7	2.2	2.8	3.3	3.5	3.3
18.00	*	3.5	3.7	3.3	3.5	3.6	3.6	4.2	4.1	3.9
20.00	*	4.5	4.8	4.2	4.4	3.6	4.4	5.0	5.1	4.9
22.00	*	5.0	5.3	5.4	5.5	5.6	5.5	6.0	5.8	5.5
24.00	*	6.4	6.9	6.2	6.1	6.6	6.2	6.7	7.3	6.9
26.00	*	7.1	7.7	7.7	7.5	8.4	7.5	7.9	8.2	7.7
28.00	*	9.2	10.0	9.9	9.2	9.0	9.3	10.1	10.5	9.9
30.00	*	10.6	11.5	11.3	10.7	10.8	10.8	11.4	12.0	11.4
32.00	*	13.7	14.6	13.4	12.4	12.0	12.5	13.7	15.2	14.5
34.00	*	14.4	15.3	15.4	14.7	13.6	14.9	15.9	15.9	15.3
36.00	*	17.9	18.7	17.7	16.8	15.9	17.0	18.6	19.4	18.7
38.00	*	19.7	20.5	19.8	19.3	19.3	19.6	20.9	21.3	20.7
40.00	*	22.8	23.5	22.3	21.7	21.2	22.0	23.8	24.3	23.9
42.00	*	24.4	25.0	25.5	25.3	26.1	25.5	27.0	25.9	25.6
44.00	*	27.9	28.4	27.7	27.3	28.7	27.4	29.3	29.5	29.3
46.00	*	30.6	30.9	31.3	31.7	33.8	31.7	32.8	32.3	32.1
48.00	*	34.1	34.3	35.2	35.4	35.2	35.3	36.7	35.8	35.7
50.00	*	37.3	37.4	38.1	38.6	40.0	38.5	39.4	39.0	38.8
52.00	*	41.4	41.5	41.8	42.4	42.6	42.3	43.1	43.0	42.8
54.00	*	43.7	43.7	45.2	46.2	46.9	46.0	46.5	45.4	45.0
56.00	*	48.0	48.0	49.6	50.3	49.9	50.2	50.9	49.5	49.1
58.00	*	51.2	51.2	52.3	53.0	54.6	52.9	53.8	52.6	52.2
60.00	*	54.6	54.6	55.9	56.8	58.1	56.6	57.4	55.9	55.6
62.00	*	57.0	56.9	59.2	60.3	62.2	60.1	60.6	58.1	58.0
64.00	*	61.0	60.8	61.7	62.9	65.5	62.7	63.3	61.9	61.9
66.00	*	63.3	63.1	65.2	66.5	69.2	66.3	66.5	64.1	64.2
68.00	*	66.5	66.2	67.9	68.8	70.9	68.7	68.8	67.2	67.4
70.00	*	68.5	68.2	70.7	71.5	73.8	71.4	71.3	69.0	69.3
72.00	*	71.4	71.2	72.8	73.6	75.8	73.5	73.2	71.8	72.1
74.00	*	73.0	72.7	75.3	75.7	77.6	75.7	75.4	73.2	73.5
76.00	*	75.6	75.4	77.3	77.5	78.8	77.5	77.2	75.6	75.8
78.00	*	77.2	77.0	79.5	78.7	80.1	78.7	78.3	77.1	77.2
80.00	*	78.9	78.7	80.0	80.0	81.0	80.1	79.9	78.7	78.9

Table A27

ENCIRCLED ENERGY

Cube #5

CIRCLE *

RADIUS *

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

(MI-
CRONS)

* CENTER (MICRONS):

* X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 -10.13 -10.13

*

5.00	*	0.1	0.1	0.3	0.2	0.5	0.2	0.3	0.3	0.3
10.00	*	0.7	0.7	0.9	0.7	1.3	0.7	1.1	1.2	1.1
15.00	*	2.4	2.5	2.4	2.4	2.2	2.5	3.1	3.0	2.8
20.00	*	4.5	4.8	4.2	4.4	3.6	4.4	5.0	5.1	4.9
25.00	*	6.9	7.4	7.4	7.3	7.3	7.3	7.7	7.9	7.5
30.00	*	10.6	11.5	11.3	10.7	10.8	10.8	11.4	12.0	11.4
35.00	*	16.4	17.4	16.4	15.4	15.2	15.6	17.0	17.9	17.2
40.00	*	22.8	23.5	22.3	21.7	21.2	22.0	23.8	24.3	23.9
45.00	*	29.3	29.7	29.8	30.1	31.7	30.2	31.2	30.9	30.8
50.00	*	37.3	37.4	38.1	38.6	40.0	38.5	39.4	39.0	38.8
55.00	*	46.5	46.6	47.6	48.3	49.2	48.2	48.9	48.0	47.6
60.00	*	54.6	54.6	55.9	56.8	58.1	56.6	57.4	55.9	55.6
65.00	*	62.0	61.8	63.9	65.1	67.7	64.9	65.2	62.9	63.0
70.00	*	68.5	68.2	70.7	71.5	73.8	71.4	71.3	69.0	69.3
75.00	*	74.5	74.3	76.3	76.7	78.2	76.7	76.3	74.7	74.8
80.00	*	78.9	78.7	80.0	80.0	81.0	80.1	79.9	78.7	78.9
85.00	*	81.8	81.6	82.5	82.6	83.3	82.6	82.6	81.6	81.8
90.00	*	83.8	83.7	84.2	84.3	84.8	84.3	84.5	83.8	84.0
95.00	*	85.5	85.5	85.7	85.7	85.9	85.7	85.9	85.6	85.6
100.00	*	86.8	86.9	87.0	86.9	87.0	86.9	86.9	86.8	86.8
105.00	*	87.8	87.9	88.1	88.1	88.2	88.1	87.9	87.8	87.7
110.00	*	88.8	88.8	89.0	89.1	89.2	89.1	88.8	88.7	88.7
115.00	*	89.8	89.7	89.8	89.9	90.0	89.9	89.7	89.6	89.7
120.00	*	90.5	90.4	90.5	90.6	90.7	90.6	90.6	90.4	90.5
125.00	*	91.1	91.0	91.2	91.2	91.3	91.2	91.2	91.0	91.1
130.00	*	91.6	91.7	91.7	91.7	91.8	91.7	91.7	91.6	91.6
135.00	*	92.1	92.1	92.1	92.1	92.2	92.1	92.2	92.1	92.2
140.00	*	92.5	92.5	92.6	92.6	92.6	92.7	92.7	92.6	92.6
145.00	*	92.9	93.0	93.0	93.0	93.0	93.1	93.1	93.0	93.0
150.00	*	93.3	93.3	93.3	93.4	93.5	93.4	93.4	93.4	93.4
155.00	*	93.6	93.6	93.7	93.8	93.9	93.8	93.8	93.7	93.7
160.00	*	94.0	94.0	94.0	94.1	94.1	94.0	94.1	94.1	94.1
165.00	*	94.3	94.3	94.3	94.4	94.4	94.4	94.4	94.4	94.4
170.00	*	94.6	94.6	94.6	94.7	94.6	94.7	94.7	94.6	94.7
175.00	*	94.9	94.8	94.9	94.9	94.9	94.9	94.9	94.9	94.9
180.00	*	95.2	95.2	95.2	95.2	95.3	95.2	95.2	95.3	95.2
184.99	*	95.4	95.5	95.4	95.5	95.5	95.5	95.5	95.6	95.5
189.99	*	95.7	95.7	95.7	95.8	95.8	95.8	95.8	95.8	95.8
194.99	*	96.0	95.9	95.9	96.0	96.1	96.0	96.1	96.1	96.1
199.99	*	96.3	96.2	96.2	96.3	96.3	96.3	96.3	96.3	96.3

Figure A73

Wavefront Map - Q Polarization

Cube #6

- MAP IN UNITS OF 0.01 WAVES

[illegible]

ORIGINAL PAGE IS
OF POOR QUALITY

Figure A75

Havelmont Map - P Polarization

Cube #6

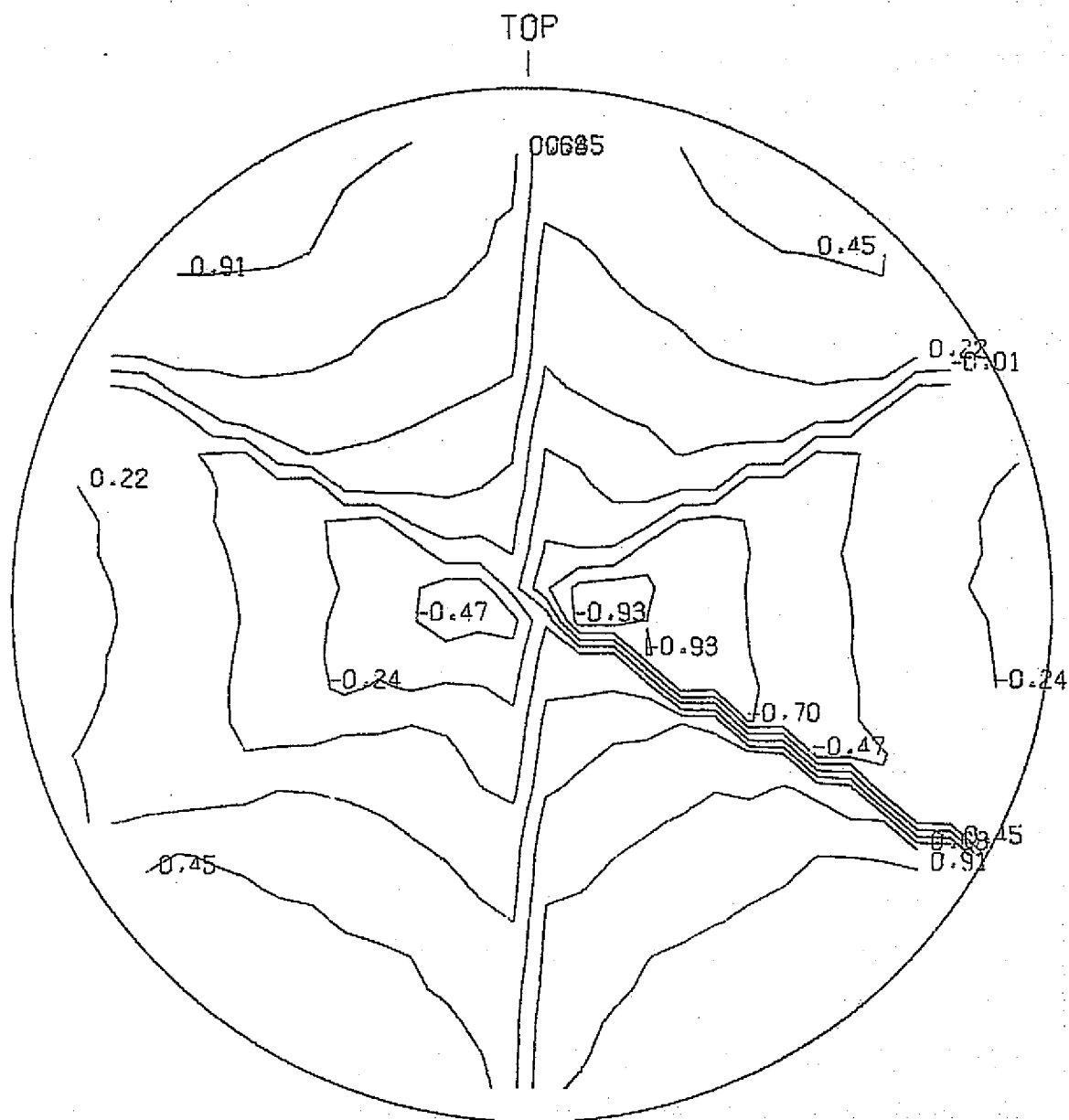
~~MAP IN UNITS OF 0.01 WAVES~~

ORIGINAL PAGE IS
OF POOR QUALITY

2.2520

[illegible]

Figure A76
Wavefront Plot - P Polarization
Cube #6



ORIGINAL PAGE IS
OF POOR QUALITY

Figure A78
Point Spread Function
Cube #6

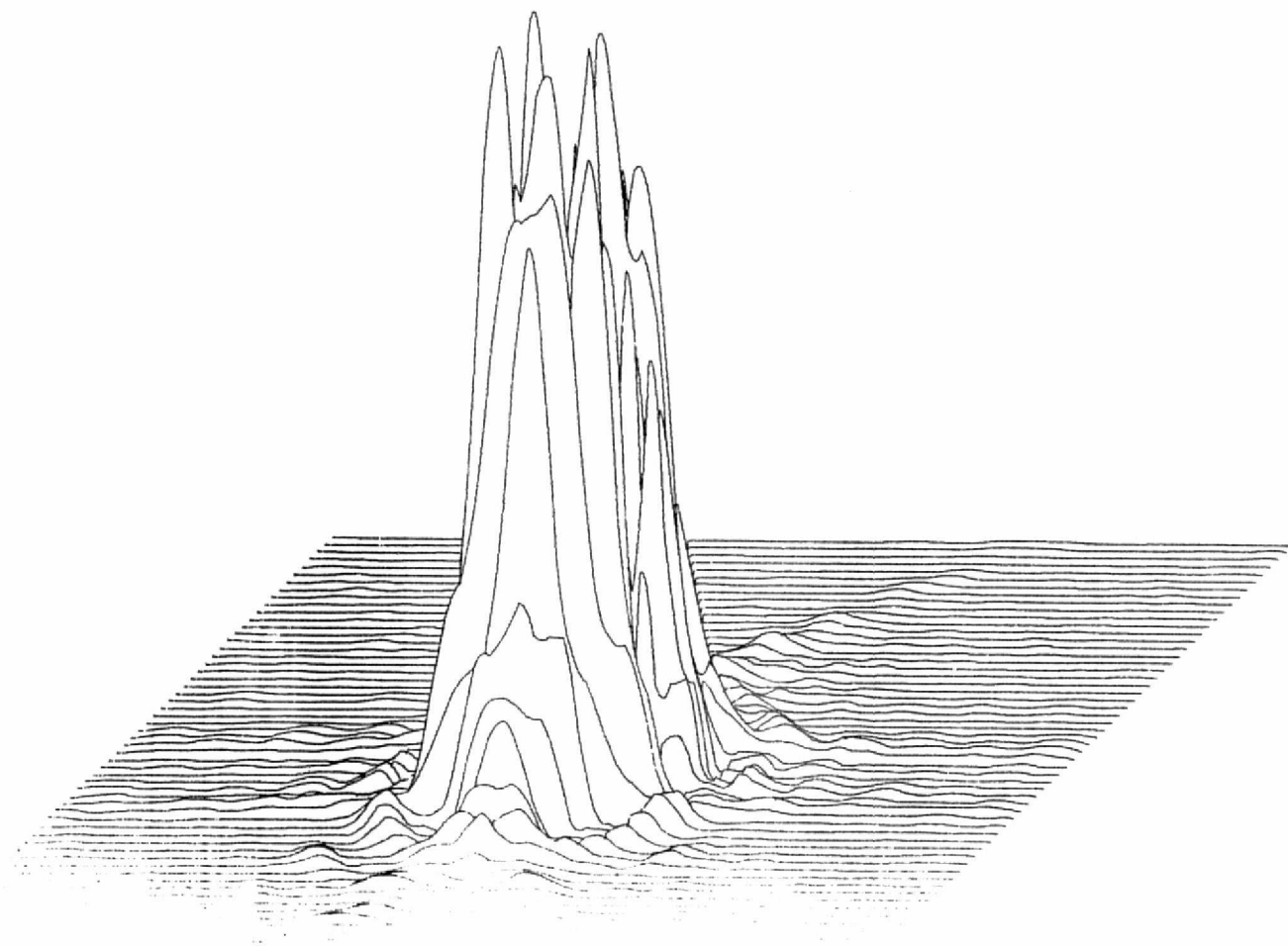
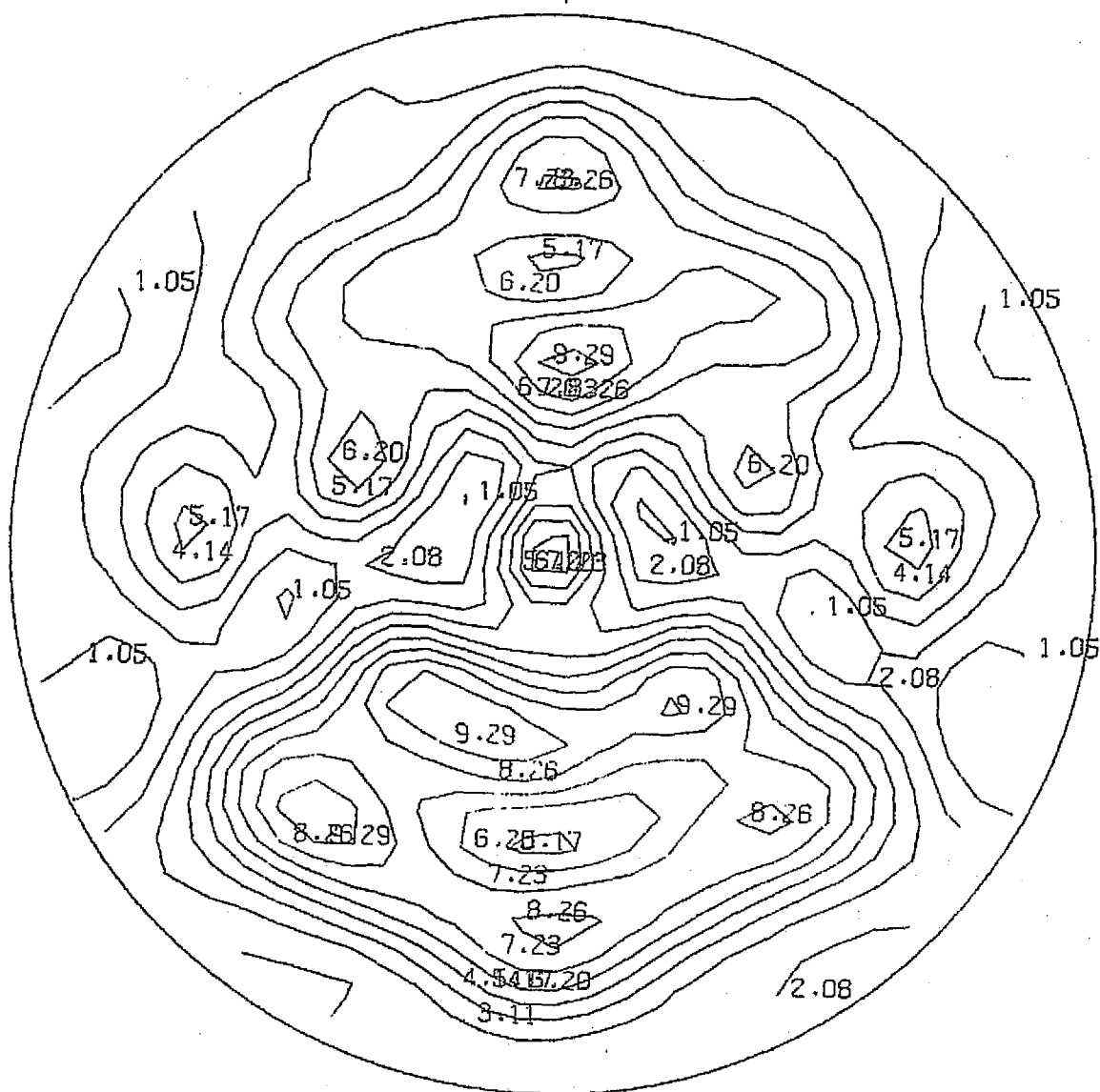


Figure A79

Intensity Distribution - Central 129 Microradians

Cube #6

TOP



ORIGINAL PAGE IS
OF POOR QUALITY

K&E 10 X 10 TO 15 INCH - 75% X 10 INCHES
PILUFFEL & ESSER CO. MADE IN USA

46 1472

Figure A80

Encircled Energy
Vs
Field Angle

Cube #6

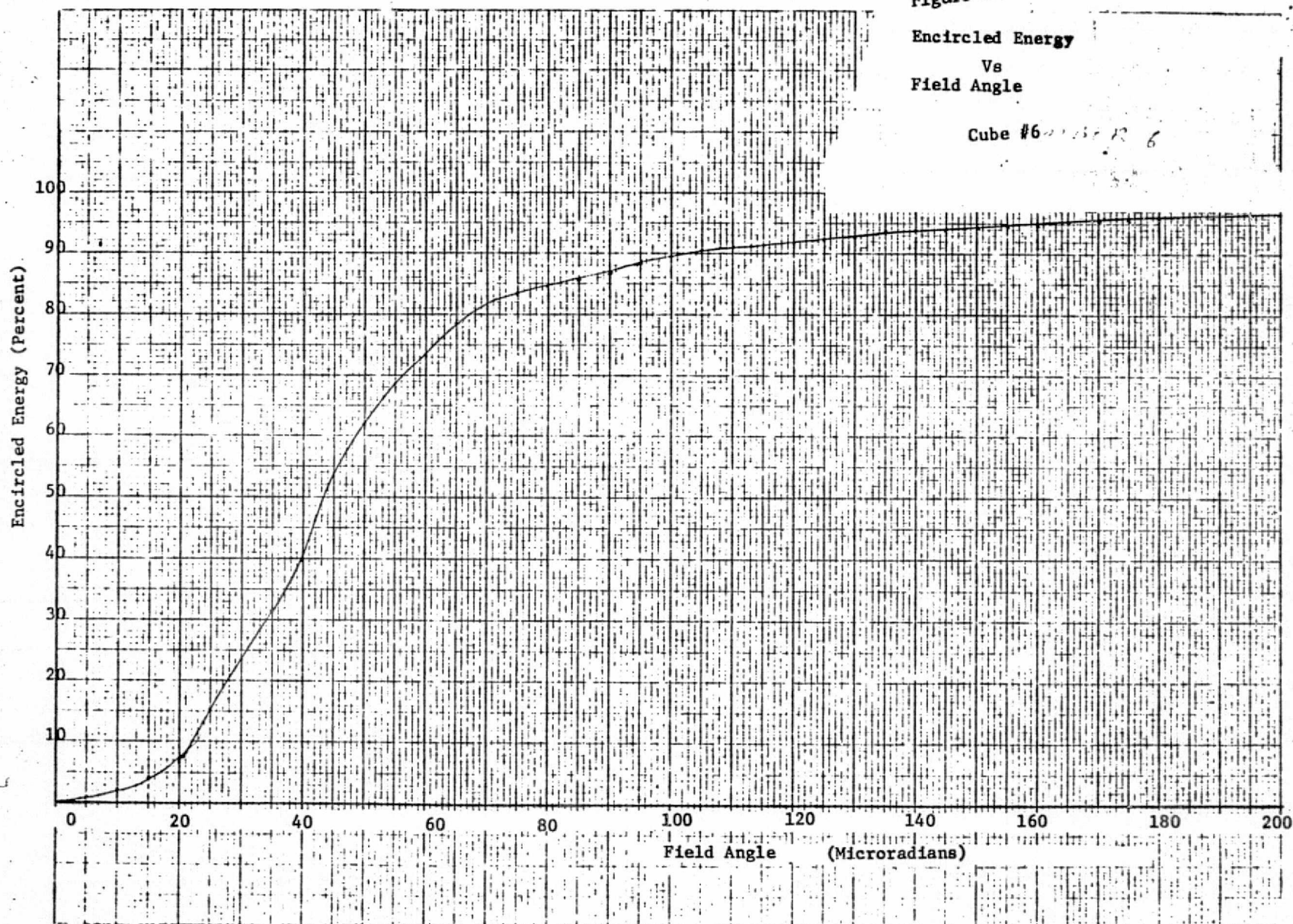


Table A28

ENCIRCLED ENERGY

Cube #6

CIRCLE

RADIUS

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

(41-
CRJNS)

* CENTER (MICRONS):

* X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13

2.00	*	0.0	0.0	0.1	0.0	0.2	0.0	0.1	0.0	0.0
4.00	*	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.5	0.5
6.00	*	0.2	0.2	0.7	0.3	1.3	0.3	0.9	0.5	0.5
8.00	*	0.8	0.9	1.4	0.8	1.3	0.8	1.6	1.6	1.6
10.00	*	1.3	1.4	1.8	1.1	2.2	1.1	2.3	2.2	2.2
12.00	*	3.3	3.4	3.1	2.2	2.4	2.2	3.8	4.5	4.4
14.00	*	3.3	3.4	4.0	3.6	3.3	3.7	5.5	4.5	4.4
16.00	*	5.9	6.1	5.5	4.8	4.0	4.9	7.1	7.2	7.0
18.00	*	7.1	7.3	6.8	6.6	6.9	6.7	8.8	8.5	8.3
20.00	*	9.3	9.5	8.9	8.4	6.9	8.5	10.8	10.6	10.4
22.00	*	10.3	10.6	10.9	11.0	11.3	11.0	12.7	11.9	11.7
24.00	*	13.1	13.4	12.6	12.3	13.4	12.3	14.3	14.7	14.5
26.00	*	14.4	14.8	15.5	15.4	17.8	15.5	16.6	16.2	16.0
28.00	*	17.9	18.4	19.3	18.9	19.1	19.0	20.5	19.8	19.6
30.00	*	20.3	20.9	22.0	22.0	23.4	22.1	22.7	22.5	22.2
32.00	*	25.4	26.0	25.6	24.9	25.7	25.0	26.5	27.4	27.2
34.00	*	26.5	27.0	28.9	29.0	28.6	29.2	30.0	28.6	28.3
36.00	*	31.9	32.4	32.9	32.3	32.4	32.5	34.5	33.9	33.6
38.00	*	34.5	35.0	36.0	36.1	37.4	36.2	37.7	36.5	36.3
40.00	*	38.8	39.2	39.7	39.5	39.9	39.6	42.0	40.7	40.6
42.00	*	41.1	41.4	43.5	44.1	46.2	44.3	45.8	43.0	42.9
44.00	*	45.5	45.6	46.2	46.3	43.5	46.4	48.9	47.1	47.2
46.00	*	48.4	48.4	50.1	51.4	55.6	51.4	52.5	50.1	50.2
48.00	*	52.1	52.0	54.2	55.0	57.0	55.0	56.3	53.6	53.9
50.00	*	55.1	55.0	56.9	58.2	62.0	58.2	58.4	56.6	56.9
52.00	*	58.9	58.7	60.7	61.7	64.0	61.7	61.9	60.0	60.2
54.00	*	61.0	60.6	63.7	64.9	67.2	64.9	64.2	62.0	62.3
56.00	*	64.9	64.7	67.5	68.2	69.0	58.2	67.7	65.4	65.6
58.00	*	67.5	67.3	69.3	70.1	71.8	70.1	69.4	67.8	67.9
60.00	*	70.2	70.0	72.1	72.5	73.6	72.5	72.0	70.2	70.3
62.00	*	72.0	71.8	73.7	74.4	75.7	74.5	73.7	71.9	72.0
64.00	*	74.6	74.5	75.4	75.8	77.3	75.8	75.6	74.4	74.5
66.00	*	75.9	75.9	77.1	77.6	79.3	77.6	77.3	75.9	75.9
68.00	*	77.7	77.6	78.6	78.7	80.0	78.8	78.7	77.7	77.8
70.00	*	78.7	78.6	79.8	80.1	81.4	80.1	80.0	78.7	78.8
72.00	*	80.2	80.2	81.0	81.0	82.2	81.0	81.1	80.2	80.3
74.00	*	80.9	80.9	82.1	82.2	83.1	82.1	82.0	81.0	81.0
76.00	*	82.2	82.2	83.1	83.0	83.5	82.9	82.9	82.2	82.3
78.00	*	83.0	83.0	83.6	83.7	84.2	83.7	83.4	83.0	83.0
80.00	*	83.9	83.9	84.4	84.3	84.5	84.3	84.2	83.9	83.9

Table A29

ENCIRCLED ENERGY

Cube #6

CIRCLE *
 ----- * PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES
 RADIUS *

(MI- * CENTER (MICRONS):
 CRONS) * X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13
 * Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13
 *

5.00	*	0.2	0.2	0.6	0.3	0.8	0.3	0.7	0.5	0.5
10.00	*	1.3	1.4	1.8	1.1	2.2	1.1	2.3	2.2	2.2
15.00	*	4.9	5.0	5.1	4.2	4.0	4.3	6.6	6.1	6.0
20.00	*	9.3	9.5	8.9	8.4	6.9	8.5	10.8	10.6	10.4
25.00	*	14.0	14.3	14.8	15.1	15.2	15.1	16.2	15.7	15.5
30.00	*	20.3	20.9	22.0	22.0	23.4	22.1	22.7	22.5	22.2
35.00	*	29.8	30.3	30.9	30.1	31.4	30.2	31.9	31.6	31.4
40.00	*	38.8	39.2	39.7	39.5	39.9	39.6	42.0	40.7	40.6
45.00	*	47.0	47.1	48.5	49.7	53.2	49.7	50.9	48.8	48.9
50.00	*	55.1	55.0	56.9	59.2	62.0	58.2	58.4	56.6	56.9
55.00	*	63.5	63.3	65.9	66.7	68.6	66.6	66.3	64.1	64.3
60.00	*	70.2	70.0	72.1	72.5	73.6	72.5	72.0	70.2	70.3
65.00	*	75.2	75.1	76.5	76.9	78.5	76.9	76.6	75.1	75.2
70.00	*	78.7	78.6	79.8	80.1	81.4	80.1	80.0	78.7	78.8
75.00	*	81.7	81.7	82.6	82.6	83.3	82.6	82.6	81.7	81.8
80.00	*	83.9	83.9	84.4	84.3	84.5	84.3	84.2	83.9	83.9
85.00	*	85.5	85.4	85.7	85.8	85.8	85.8	85.7	85.4	85.4
90.00	*	86.7	86.7	86.8	87.0	86.9	87.3	86.9	86.7	86.8
95.00	*	87.9	87.9	87.9	88.1	88.2	88.1	88.1	88.0	88.0
100.00	*	88.9	88.9	89.0	89.1	89.4	89.1	89.1	88.9	88.9
105.00	*	89.8	89.7	90.0	90.0	90.3	90.3	89.9	89.7	89.7
110.00	*	90.6	90.6	90.8	90.7	91.0	90.8	90.6	90.5	90.4
115.00	*	91.3	91.3	91.4	91.3	91.4	91.3	91.2	91.2	91.2
120.00	*	91.8	91.9	91.8	91.8	91.8	91.3	91.8	91.8	91.8
125.00	*	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3	92.3
130.00	*	92.7	92.7	92.7	92.7	92.8	92.8	92.7	92.7	92.7
135.00	*	93.1	93.1	93.1	93.2	93.3	93.2	93.2	93.2	93.2
140.00	*	93.5	93.5	93.5	93.6	93.6	93.6	93.7	93.6	93.6
145.00	*	93.8	93.8	93.9	94.0	94.0	94.3	94.1	94.3	94.0
150.00	*	94.2	94.2	94.2	94.3	94.3	94.3	94.4	94.3	94.3
155.00	*	94.5	94.5	94.6	94.6	94.6	94.6	94.7	94.6	94.6
160.00	*	94.8	94.8	94.8	94.9	94.8	94.9	94.9	94.9	94.9
165.00	*	95.1	95.1	95.1	95.2	95.2	95.1	95.2	95.2	95.2
170.00	*	95.4	95.4	95.4	95.4	95.4	95.4	95.5	95.5	95.5
175.00	*	95.6	95.6	95.6	95.7	95.7	95.7	95.8	95.7	95.7
180.00	*	95.9	95.9	95.9	96.0	96.0	96.0	96.0	96.0	96.0
184.99	*	96.1	96.1	96.1	96.2	96.2	96.2	96.2	96.2	96.2
189.99	*	96.4	96.3	96.4	96.4	96.4	96.4	96.5	96.4	96.4
194.99	*	96.6	96.6	96.6	96.6	96.7	96.6	96.6	96.6	96.6
199.99	*	96.8	96.8	96.8	96.8	96.8	96.8	96.8	96.9	96.8

Figure A81

Wavefront Map - Q Polarization

Cube #1RW

MAP IN UNITS OF 0.01 WAVES

-51 -54 -53 -57 -58 -59 -57 -53 -47 -46
 -46 -48 -49 -48 -51 -51 -55 -57 -59 -56 -49 -46 -45 -40 -40 -40
 -42 -42 -42 -43 -43 -45 -48 -49 -52 -52 -49 -45 -43 -40 -38 -38 -39 -37
 -43 -41 -40 -40 -41 -42 -43 -46 -49 -53 -51 -47 -43 -41 -39 -38 -38 -37 -37 -39
 -42 -41 -40 -38 -39 -40 -42 -42 -45 -49 -50 -54 -49 -45 -41 -40 -39 -37 -37 -37 -38 -38
 -44 -41 -37 -37 -37 -38 -39 -40 -42 -43 -47 -53 -53 -51 -46 -43 -41 -40 -38 -38 -36 -38 -39 -42
 -45 -42 -39 -36 -37 -37 -37 -39 -41 -42 -44 -46 -57 -55 -50 -47 -43 -42 -40 -39 -39 -39 -39 -43 -48
 32 -41 -40 -39 -37 -37 -38 -38 -40 -43 -45 -46 -49 -55 -53 -51 -48 -45 -43 -43 -40 -40 -40 -41 -43 -47 -42 22
 32 32 40 -34 -37 -38 -38 -40 -41 -44 -46 -48 -52 -54 -53 -53 -50 -48 -44 -44 -43 -43 -42 -42 -36 27 31 29
 32 33 35 -37 -32 -36 -40 -42 -44 -45 -46 -50 -53 -55 -58 -54 -51 -50 -47 -46 -47 -45 -43 -42 -36 -35 -32 -30
 31 33 36 36 37 36 28 -49 -47 -46 -48 -49 -53 -55 -61 -65 -57 -54 -53 -51 -50 -44 -50 27 31 34 36 38 35 33
 35 36 37 38 28 37 32 32 26 -44 -47 -51 -55 -57 -65 -65 -61 -57 -54 -55 -47 27 29 30 33 35 37 38 38 35
 36 39 39 35 39 38 33 28 30 28 25 -56 -58 -61 -66 -64 -62 -61 -60 19 23 25 28 30 35 37 39 40 39 38
 40 41 40 39 39 37 34 30 27 25 20 12 -63 -66 -69 -68 -68 -65 7 20 23 26 29 33 36 37 39 40 40 39
 41 41 40 40 39 36 34 31 27 24 19 16 12 -1 -66 -70 0 7 16 19 24 27 30 33 35 39 40 41 41 40
 40 41 41 40 39 35 33 30 27 24 19 16 7 0 -70 -66 -1 12 16 19 24 27 31 34 36 39 40 40 41 41
 39 40 40 39 27 36 33 29 26 23 20 7 -65 -68 -68 -69 -66 -63 12 20 25 27 30 34 37 39 39 40 41 40
 38 39 40 39 37 35 30 28 25 23 19 -60 -61 -62 -64 -66 -61 -58 -56 25 28 30 28 33 38 39 39 39 36
 35 38 38 37 28 33 30 29 27 -47 -55 -54 -57 -61 -65 -65 -57 -55 -51 -47 -44 -26 22 22 37 38 38 37 36 35
 33 35 38 36 34 31 27 -50 -44 -50 -51 -53 -54 -57 -65 -61 -55 -53 -49 -48 -46 -47 -49 28 36 37 36 36 33 31
 30 22 35 36 -42 -43 -45 -47 -46 -47 -50 -51 -54 -58 -55 -53 -50 -46 -45 -44 -42 -40 -36 -33 37 35 33 32
 29 31 27 -36 -42 -42 -43 -42 -44 -44 -48 -50 -53 -53 -54 -52 -48 -46 -44 -41 -40 -38 -38 -37 -34 -40 -32 -32
 22 -42 -47 -43 -41 -40 -40 -40 -43 -43 -45 -48 -51 -53 -55 -49 -46 -45 -43 -40 -38 -28 -37 -37 -39 -40 -41 32
 -48 -42 -39 -39 -39 -39 -40 -42 -43 -47 -50 -55 -57 -46 -44 -42 -41 -39 -37 -37 -27 -38 -39 -42 -45
 -42 -39 -38 -36 -38 -38 -40 -41 -43 -46 -51 -53 -53 -47 -43 -42 -40 -39 -38 -37 -37 -37 -41 -44
 -38 -38 -37 -37 -37 -35 -40 -41 -45 -49 -54 -50 -49 -45 -42 -42 -40 -39 -38 -40 -41 -43
 -39 -37 -37 -38 -38 -39 -41 -43 -47 -51 -53 -49 -46 -43 -42 -41 -40 -40 -41 -43
 -37 -39 -38 -38 -40 -43 -45 -49 -52 -52 -49 -48 -45 -43 -43 -42 -42 -42
 -40 -40 -40 -45 -46 -49 -56 -59 -57 -55 -51 -51 -48 -49 -48 -46
 -46 -47 -53 -57 -59 -58 -57 -53 -54 -51

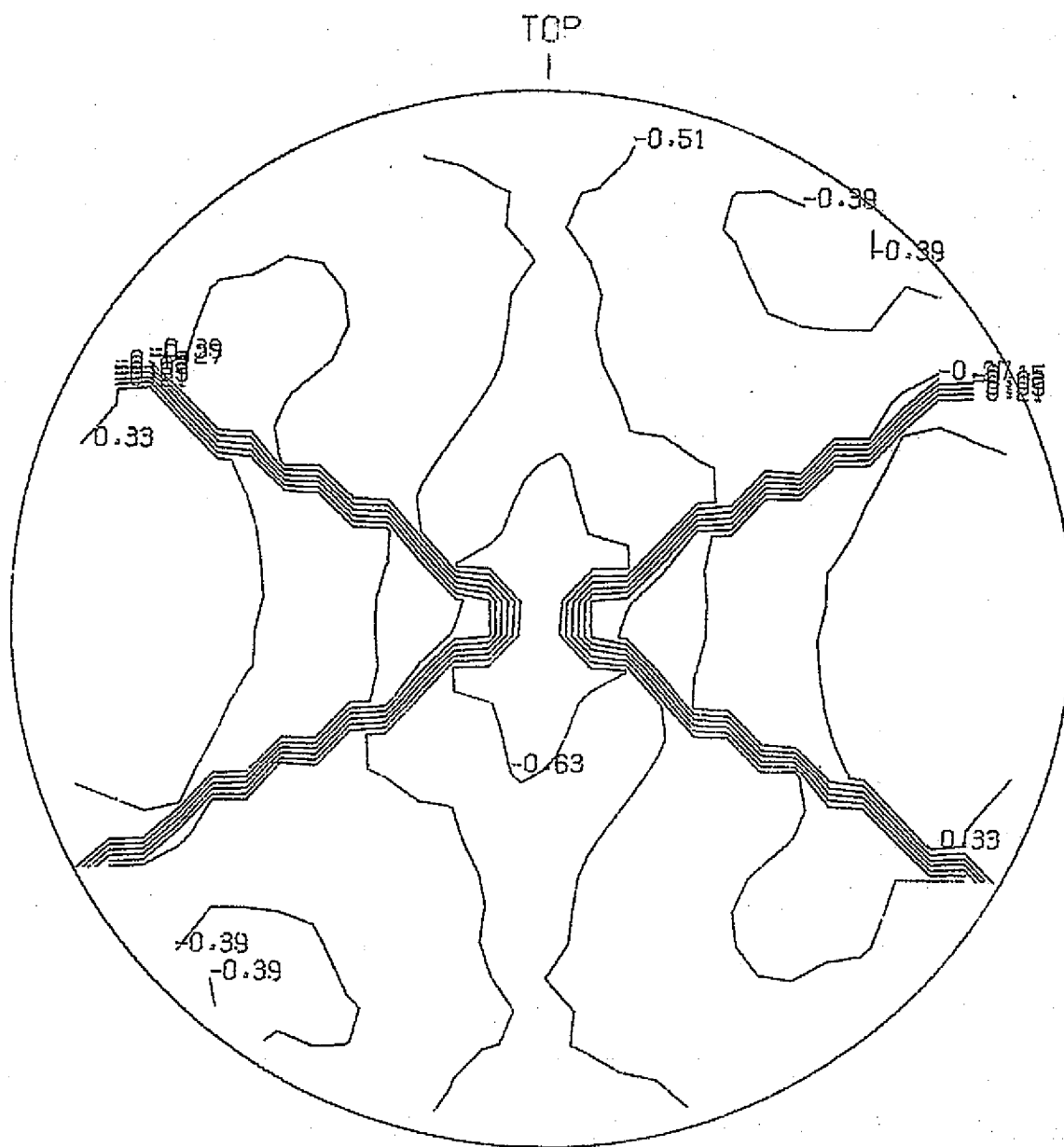
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07570

Figure A82

Wavefront Plot - Q Polarization

Cube #1RW



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OF POOR QUALITY

Cuba #IRW

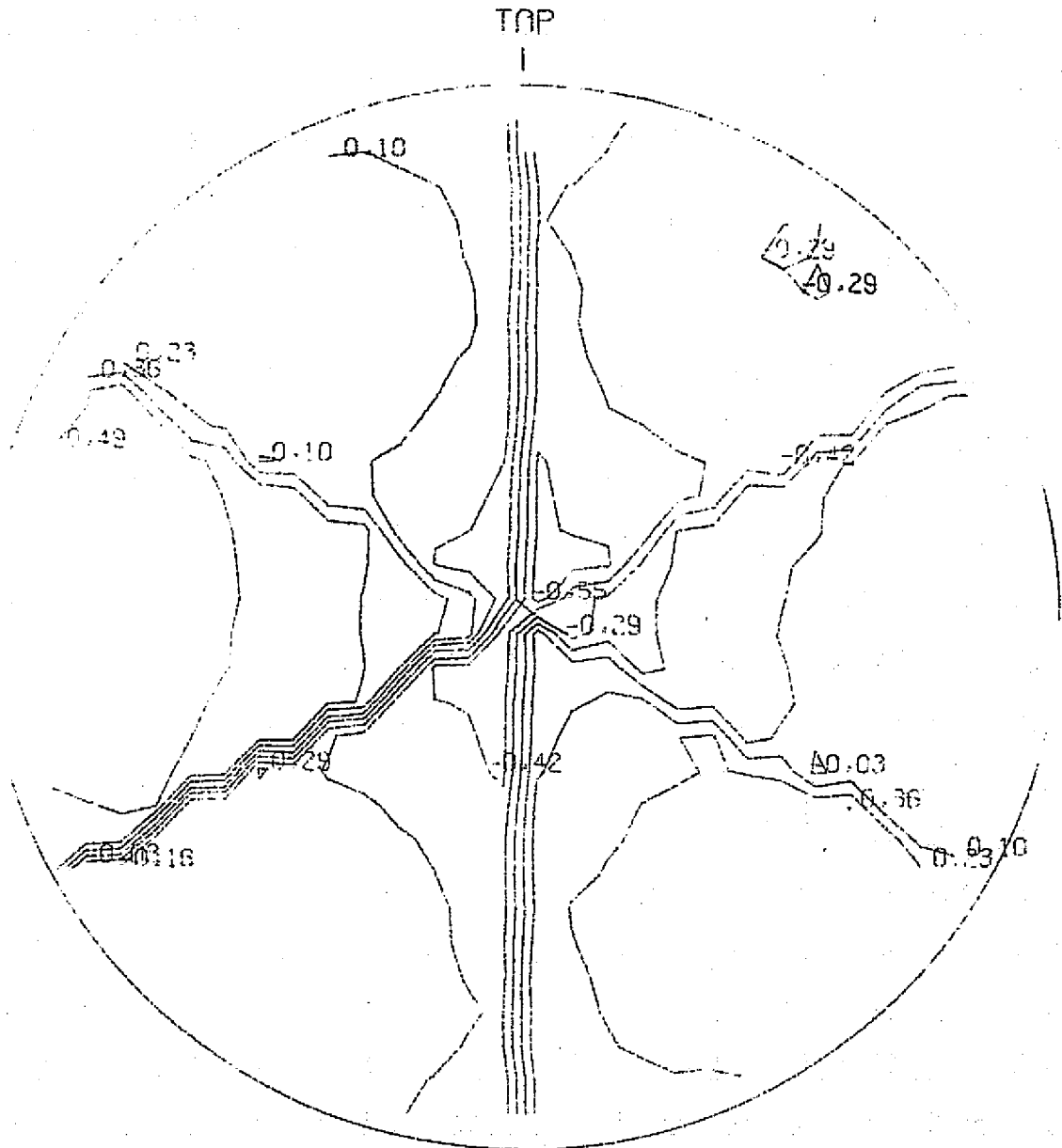
ORIGINAL PAGE IS
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[illegible]

Figure A84

Wavefront Plot - P Polarization

Cube #1RW



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A115

Figure A85

PRINTER MAP OF POINT SPREAD FUNCTION

Cube #1RW

CODE #1107
(ONE SPACE REPRESENTS 8.04 MICRONS)

NORMALIZED SO LARGEST VALUE = 0.1278 = 100

TOTAL ENERGY = 0.24610000D+01

MAP REPRESENTS C.2302223D+01 OR 93.5483 PERCENT CF TCTAL ENERGY

[illegible]

IC
IC

Figure A86

Point Spread Function

Cube #1RW

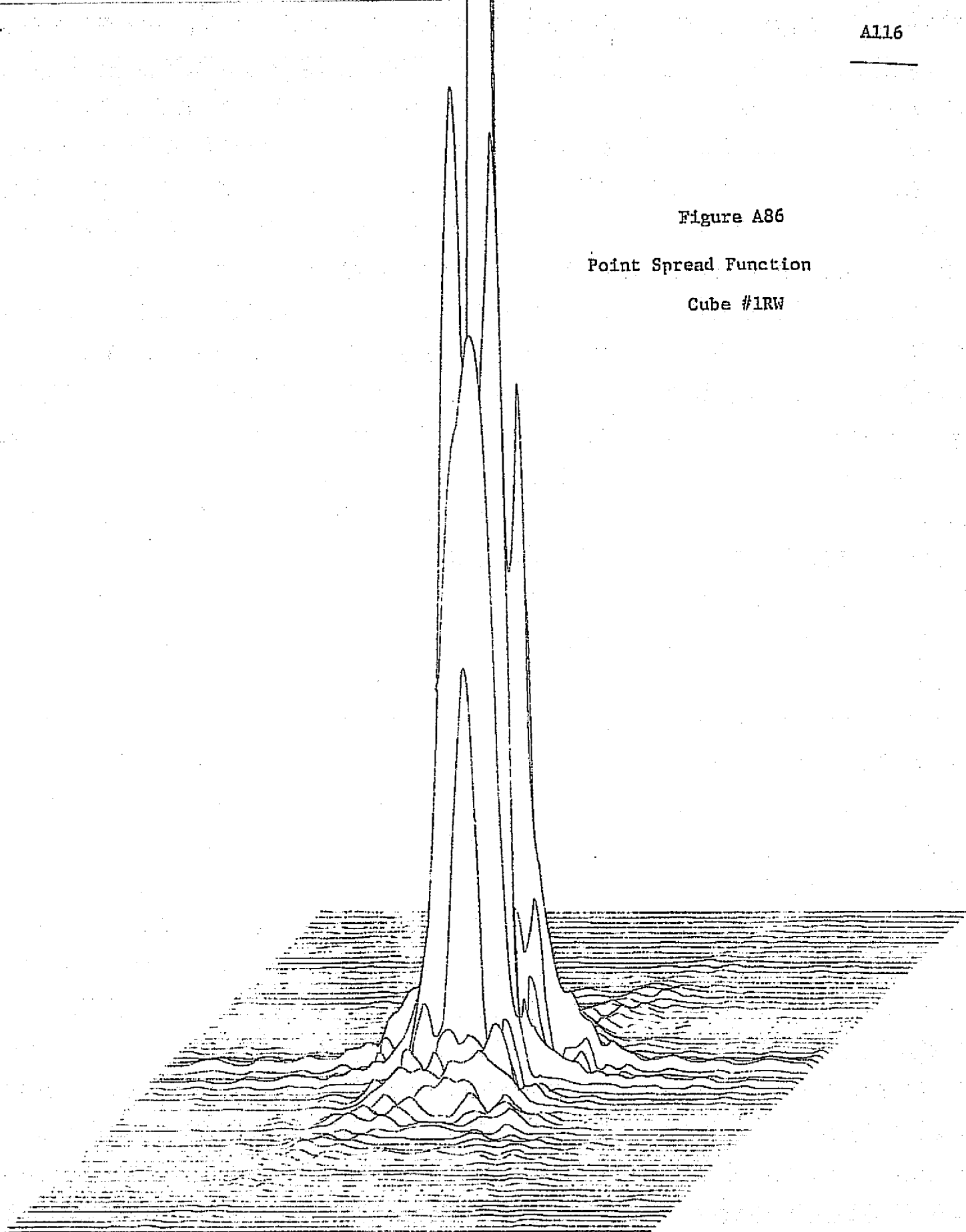


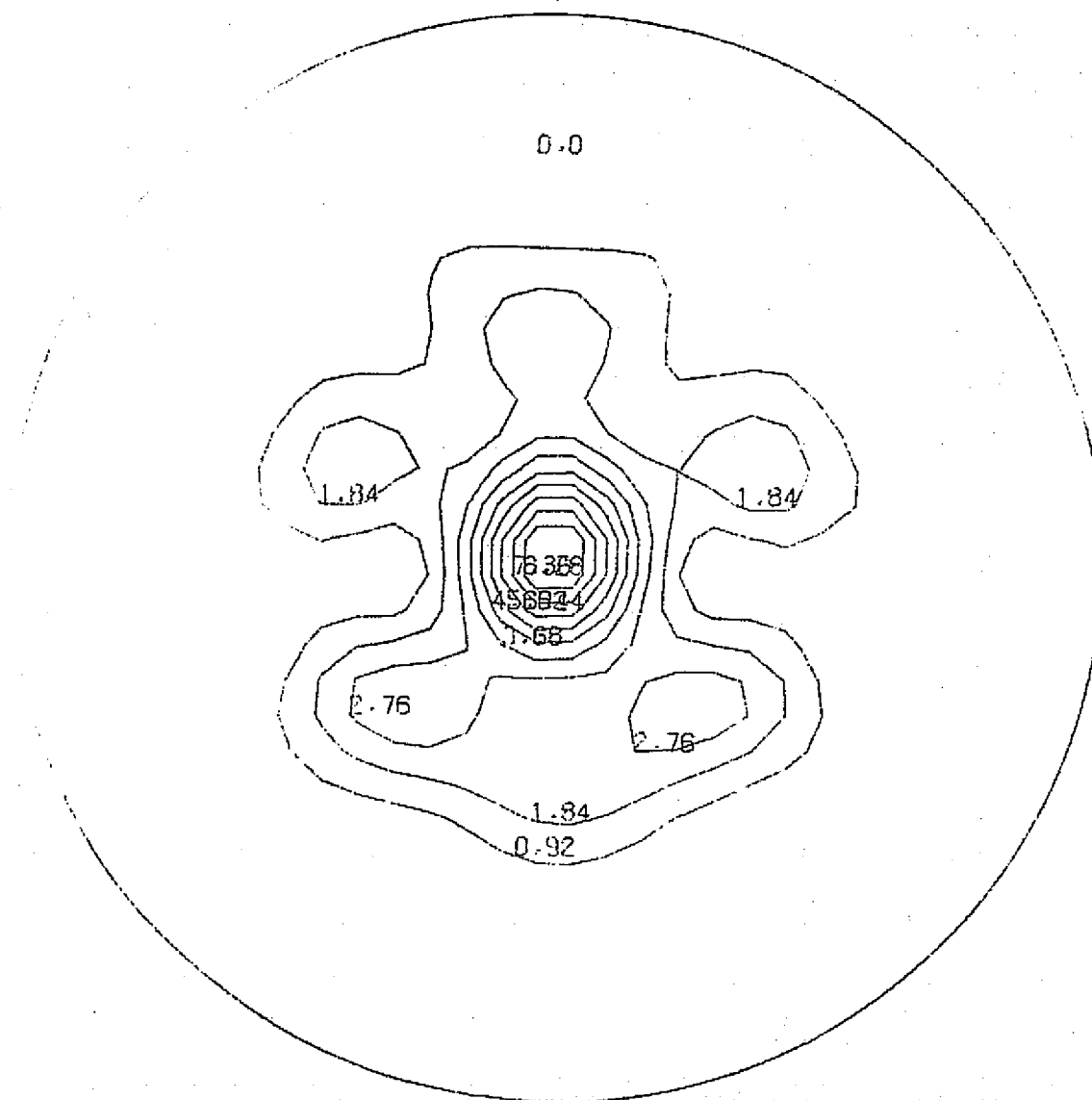
Figure A87

Intensity Distribution - Central 129 Microradians.

Cube #1RW

TOP

I



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OF POOR QUALITY

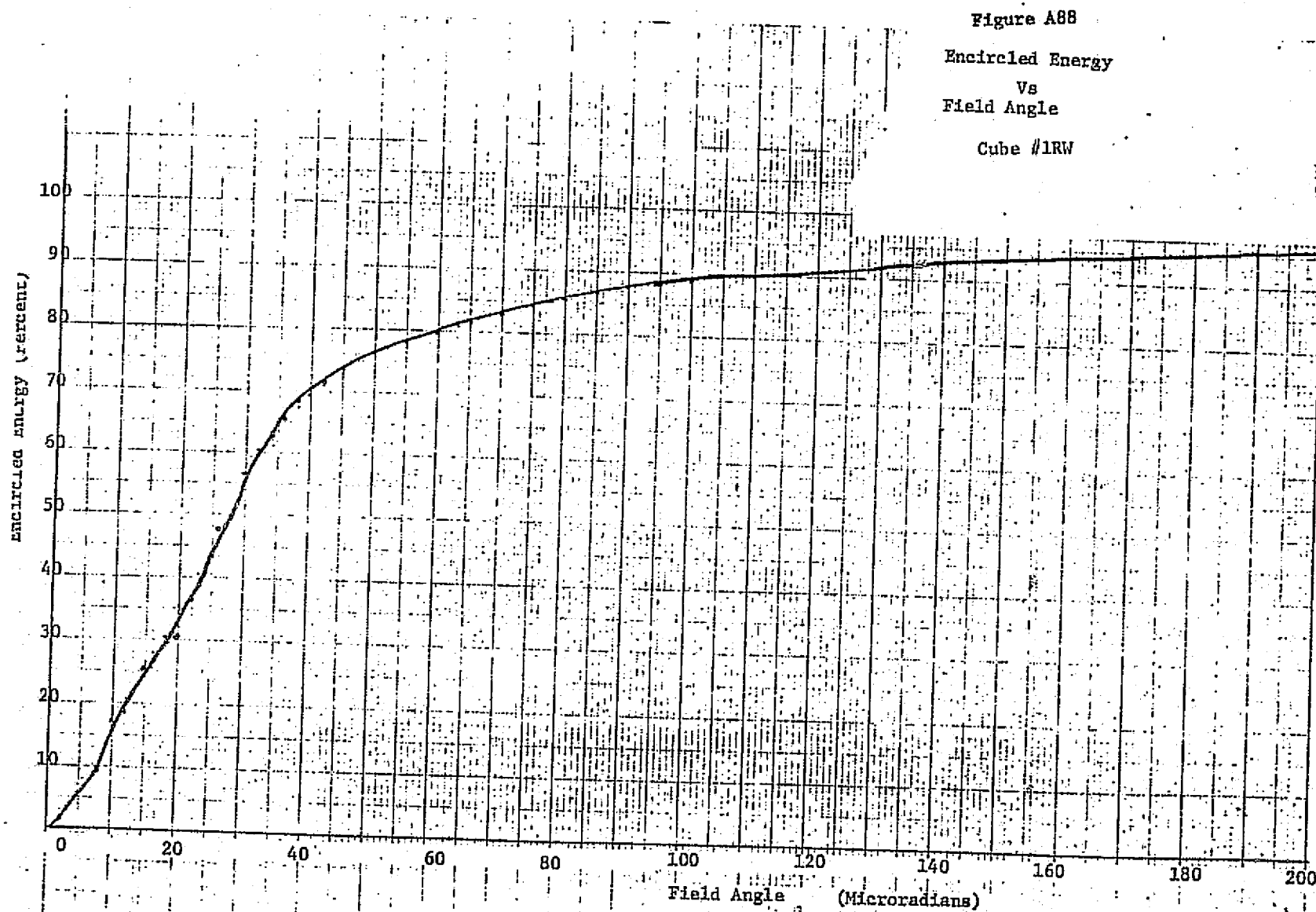


Table A30

A119

ENCIRCLED ENERGY

Cube #1RW

CIRCLE *

RADIUS *

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

(MI-
CRONS)

* CENTER (MICRONS):

* X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13

*

2.00	*	0.0	0.0	0.5	0.3	1.3	0.3	0.5	0.0	0.0
4.00	*	1.1	1.2	1.2	0.9	1.3	0.9	1.2	1.5	1.4
6.00	*	1.1	1.2	3.6	2.6	9.5	2.6	3.7	1.5	1.4
8.00	*	3.7	3.8	7.1	5.8	9.5	5.8	7.3	4.7	4.5
10.00	*	5.2	5.4	8.7	7.2	17.1	7.2	9.2	6.5	6.2
12.00	*	11.6	11.7	14.1	12.6	18.8	12.6	15.1	13.6	13.3
14.00	*	11.6	11.7	17.6	17.2	22.9	17.1	19.6	13.6	13.3
16.00	*	19.3	19.2	22.4	22.0	25.2	21.9	25.0	21.8	21.6
18.00	*	22.4	22.4	25.5	26.1	30.4	25.9	28.9	25.4	25.2
20.00	*	27.4	27.3	30.9	31.9	30.4	31.8	35.2	30.6	30.5
22.00	*	30.6	30.5	33.9	36.2	36.8	36.1	38.7	34.2	34.1
24.00	*	36.1	36.0	37.2	39.0	40.4	38.9	42.1	39.7	39.6
26.00	*	38.3	38.4	41.1	43.6	47.5	43.5	45.7	42.4	42.3
28.00	*	43.0	43.1	45.2	48.0	49.5	47.9	50.0	46.5	46.3
30.00	*	46.1	46.3	49.0	51.7	56.2	51.6	52.4	50.0	49.7
32.00	*	51.6	51.8	52.5	54.9	59.1	54.8	55.5	54.4	54.1
34.00	*	52.5	52.7	56.5	58.9	62.7	58.9	58.3	55.3	55.1
36.00	*	58.0	58.2	60.4	62.0	65.5	62.0	61.4	59.6	59.3
38.00	*	60.4	60.6	63.6	65.2	68.1	65.2	63.2	61.3	61.2
40.00	*	64.0	64.0	66.8	67.7	69.2	67.7	66.1	64.3	64.2
42.00	*	66.2	66.1	69.4	69.9	71.5	70.0	68.2	65.9	66.0
44.00	*	69.5	69.3	71.0	71.3	72.5	71.3	70.2	68.7	68.8
46.00	*	71.0	70.8	72.8	72.6	74.2	72.6	72.1	70.2	70.4
48.00	*	73.0	72.7	74.2	73.9	74.7	73.9	73.9	72.3	72.7
50.00	*	74.2	73.9	75.2	74.5	76.1	74.5	75.1	73.8	74.1
52.00	*	75.5	75.2	76.1	75.7	76.7	75.8	76.4	75.2	75.6
54.00	*	76.1	75.8	77.1	76.5	77.6	76.5	77.5	76.1	76.5
56.00	*	77.3	77.1	77.9	77.6	78.1	77.7	78.6	77.4	77.7
58.00	*	77.9	77.8	78.6	78.3	79.1	78.4	79.2	78.4	78.5
60.00	*	78.9	78.8	79.2	79.2	79.7	79.3	79.9	79.2	79.4
62.00	*	79.4	79.4	80.0	80.0	80.5	80.1	80.5	79.8	79.9
64.00	*	80.4	80.4	80.5	80.7	81.1	80.8	80.9	80.7	80.7
66.00	*	80.5	81.0	81.3	81.5	81.9	81.6	81.5	81.2	81.2
68.00	*	81.7	81.9	81.8	82.2	82.3	82.2	81.9	81.9	81.9
70.00	*	82.2	82.3	82.5	82.8	82.9	82.8	82.5	82.3	82.3
72.00	*	83.0	83.1	83.1	83.4	83.4	83.4	83.0	83.0	83.0
74.00	*	83.3	83.4	83.8	83.9	84.0	83.9	83.6	83.4	83.3
76.00	*	84.1	84.2	84.3	84.5	84.4	84.4	84.1	84.0	83.9
78.00	*	84.5	84.6	84.8	84.8	85.0	84.7	84.6	84.5	84.4
80.00	*	85.0	85.1	85.2	85.3	85.4	85.2	85.1	85.0	84.9

Table A31

A120

ENCIRCLED ENERGY

Cube #1RW

CIRCLE *

* PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

RADIUS *

(MI-
CRONS)

* CENTER (MICRONS):

* X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13

*

5.00	*	1.1	1.2	3.3	2.6	5.7	2.6	3.4	1.5	1.4
10.00	*	5.2	5.4	8.7	7.2	17.1	7.2	9.2	6.5	6.2
15.00	*	16.3	16.2	21.6	20.5	25.2	20.4	23.7	18.5	18.3
20.00	*	27.4	27.3	30.9	31.9	30.4	31.8	35.2	30.6	30.5
25.00	*	37.6	37.6	40.1	42.9	43.1	42.7	45.1	41.4	41.4
30.00	*	46.1	46.3	49.0	51.7	56.2	51.6	52.4	50.0	49.7
35.00	*	56.2	56.5	58.5	60.2	64.8	60.1	59.5	57.9	57.5
40.00	*	64.0	64.0	66.8	67.7	69.2	67.7	66.1	64.3	64.2
45.00	*	70.3	70.1	72.2	72.0	73.5	72.0	71.3	69.7	69.9
50.00	*	74.2	73.9	75.2	74.5	76.1	74.5	75.1	73.8	74.1
55.00	*	76.9	76.7	77.5	77.2	78.0	77.3	78.0	76.9	77.2
60.00	*	78.9	78.8	79.2	79.2	79.7	79.3	79.9	79.2	79.4
65.00	*	80.6	80.7	81.0	81.2	81.6	81.2	81.2	80.9	80.9
70.00	*	82.2	82.3	82.5	82.8	82.9	82.8	82.5	82.3	82.3
75.00	*	83.8	83.9	84.0	84.2	84.2	84.2	83.9	83.7	83.6
80.00	*	85.0	85.1	85.2	85.3	85.4	85.2	85.1	85.0	84.9
85.00	*	86.0	86.0	86.4	86.2	86.6	86.2	86.4	86.0	86.0
90.00	*	86.9	86.8	87.2	87.0	87.3	87.0	87.3	87.0	87.0
95.00	*	87.8	87.8	87.8	87.8	88.0	87.9	87.9	87.9	87.9
100.00	*	88.5	88.4	88.4	88.6	88.6	88.6	88.6	88.5	88.5
105.00	*	89.0	89.0	89.1	89.2	89.2	89.2	89.2	89.1	89.1
110.00	*	89.6	89.6	89.7	89.8	89.8	89.8	89.7	89.7	89.7
115.00	*	90.2	90.3	90.3	90.2	90.4	90.2	90.3	90.2	90.2
120.00	*	90.7	90.7	90.8	90.7	90.9	90.7	90.8	90.7	90.7
125.00	*	91.1	91.1	91.3	91.2	91.2	91.2	91.3	91.2	91.1
130.00	*	91.5	91.5	91.6	91.6	91.6	91.6	91.6	91.6	91.5
135.00	*	91.9	91.9	91.9	91.9	92.0	91.9	91.9	91.9	91.9
140.00	*	92.3	92.3	92.3	92.4	92.3	92.4	92.3	92.3	92.3
145.00	*	92.6	92.7	92.7	92.7	92.6	92.7	92.7	92.7	92.6
150.00	*	93.0	93.0	93.0	93.0	93.1	93.0	93.0	93.0	93.0
155.00	*	93.3	93.3	93.4	93.3	93.5	93.3	93.4	93.3	93.3
160.00	*	93.6	93.7	93.6	93.7	93.7	93.7	93.7	93.7	93.7
165.00	*	93.9	93.9	94.0	94.0	94.0	94.0	94.0	94.0	94.0
170.00	*	94.2	94.2	94.2	94.3	94.3	94.3	94.2	94.2	94.2
175.00	*	94.5	94.5	94.5	94.5	94.4	94.5	94.5	94.5	94.5
180.00	*	94.8	94.8	94.8	94.8	94.8	94.8	94.8	94.8	94.8
184.99	*	95.1	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0
189.99	*	95.3	95.3	95.4	95.3	95.4	95.3	95.4	95.3	95.3
194.99	*	95.5	95.5	95.6	95.5	95.6	95.5	95.6	95.5	95.5
199.99	*	95.8	95.8	95.8	95.8	95.8	95.9	95.8	95.9	95.8

Figure A89

Wavefront Map - Q Polarization

Cube #2RW

MAP IN UNITS OF 0.01 WAVES

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-43 -40 -43 -47 -54 -50 -49 -45 -41 -41
 -33 -33 -33 -37 -38 -39 -45 -49 -48 -46 -41 -39 -39 -37 -37 -37
 -33 -31 -32 -32 -33 -36 -38 -41 -49 -42 -41 -38 -36 -34 -34 -35 -33 -36
 -35 -32 -32 -32 -33 -34 -36 -39 -41 -44 -40 -39 -38 -35 -33 -32 -32 -33 -35 -37
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 21 -47 -46 -45 -40 -40 -41 -38 -40 -44 -44 -47 -50 -48 -48 -48 -47 -43 -42 -39 -38 -39 -40 -40 -44 -48 -42 24
 25 25 25 -47 -41 -43 -45 -44 -44 -47 -47 -49 -53 -53 -51 -51 -49 -46 -44 -42 -41 -42 -43 -42 -44 27 31 27
 27 28 28 -27 -47 -44 -48 -47 -48 -49 -50 -53 -57 -60 -56 -56 -52 -51 -48 -46 -47 -48 -49 -42 -30 -34 -30 31
 30 30 32 31 29 25 30 -48 -51 -51 -51 -55 -59 -61 -65 -63 -59 -57 -55 -52 -50 -43 -44 26 32 33 26 35 36 33
 36 38 39 35 12 30 26 21 17 -52 -58 -62 -66 -65 -72 -69 -63 -62 -60 -58 -50 26 29 30 33 36 37 39 37 37
 38 40 40 38 36 31 27 23 19 16 10 -69 -70 -73 -77 -77 -70 -68 -65 14 19 24 27 31 35 37 40 41 42 40
 41 42 41 39 37 34 25 25 19 15 9 6 -72 -73 -75 -78 -73 -70 5 13 18 23 28 32 35 38 40 42 43 42
 43 43 41 35 28 35 30 26 23 16 10 7 0 -2 -73 -76 -6 0 6 11 19 24 28 31 35 39 40 42 44 44
 44 44 42 40 35 35 31 28 24 19 11 6 0 -6 -76 -73 -2 0 7 10 16 23 26 30 35 38 39 41 43 43
 42 43 42 40 28 25 32 28 23 18 13 5 -70 -73 -78 -75 -73 -72 6 9 15 19 25 29 34 37 39 41 42 41
 40 42 41 40 37 35 31 27 24 19 14 -65 -68 -70 -77 -77 -73 -70 -69 10 16 19 23 27 31 36 38 40 40 38
 37 37 39 37 26 33 30 29 26 -50 -58 -60 -62 -63 -69 -72 -65 -66 -62 -58 -52 -17 21 26 30 32 35 39 38 36
 32 36 35 36 22 22 26 -44 -43 -50 -52 -55 -57 -59 -63 -65 -61 -59 -55 -51 -51 -51 -48 30 25 29 31 32 30 30
 31 30 34 30 -42 -49 -48 -47 -46 -48 -51 -52 -56 -56 -60 -57 -53 -50 -49 -48 -47 -48 -44 -47 27 28 28 27
 27 31 27 -44 -42 -43 -42 -41 -42 -44 -46 -49 -51 -51 -53 -53 -49 -47 -47 -44 -44 -45 -43 -41 -47 25 25 25
 24 -42 -48 -44 -40 -40 -39 -38 -39 -42 -43 -47 -48 -48 -50 -47 -44 -44 -40 -38 -41 -40 -40 -45 -46 -47 21
 -52 -47 -42 -37 -35 -37 -26 -36 -39 -41 -43 -45 -50 -55 -47 -43 -41 -40 -38 -37 -36 -37 -37 -42 -47 -48
 -44 -42 -37 -34 -34 -35 -34 -36 -39 -41 -44 -52 -49 -44 -41 -39 -36 -35 -35 -33 -34 -36 -38 -46
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 -36 -23 -35 -34 -34 -36 -38 -41 -42 -49 -41 -38 -36 -33 -33 -32 -31 -33
 -37 -37 -37 -39 -39 -41 -46 -48 -49 -45 -39 -38 -37 -33 -33 -33
 -41 -41 -45 -49 -50 -54 -47 -43 -40 -43

20625

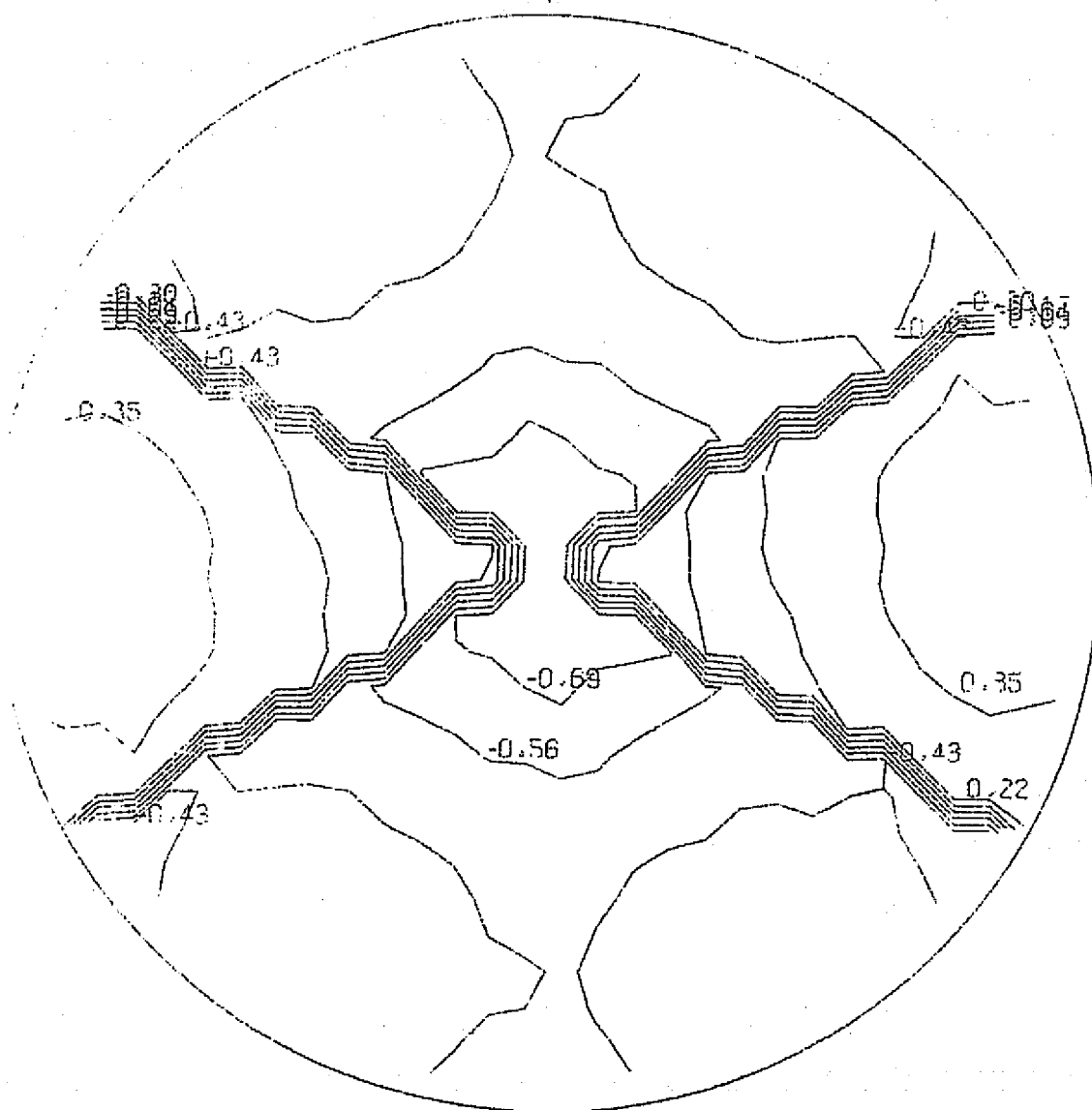
20625

Figure A90

Wavefront Plot - Q Polarization

Cube #2RW

TOP



A123

Cube #2RH

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[illegible]

Figure A92

Wavefront Plot - P Polarization

Cube #2RW

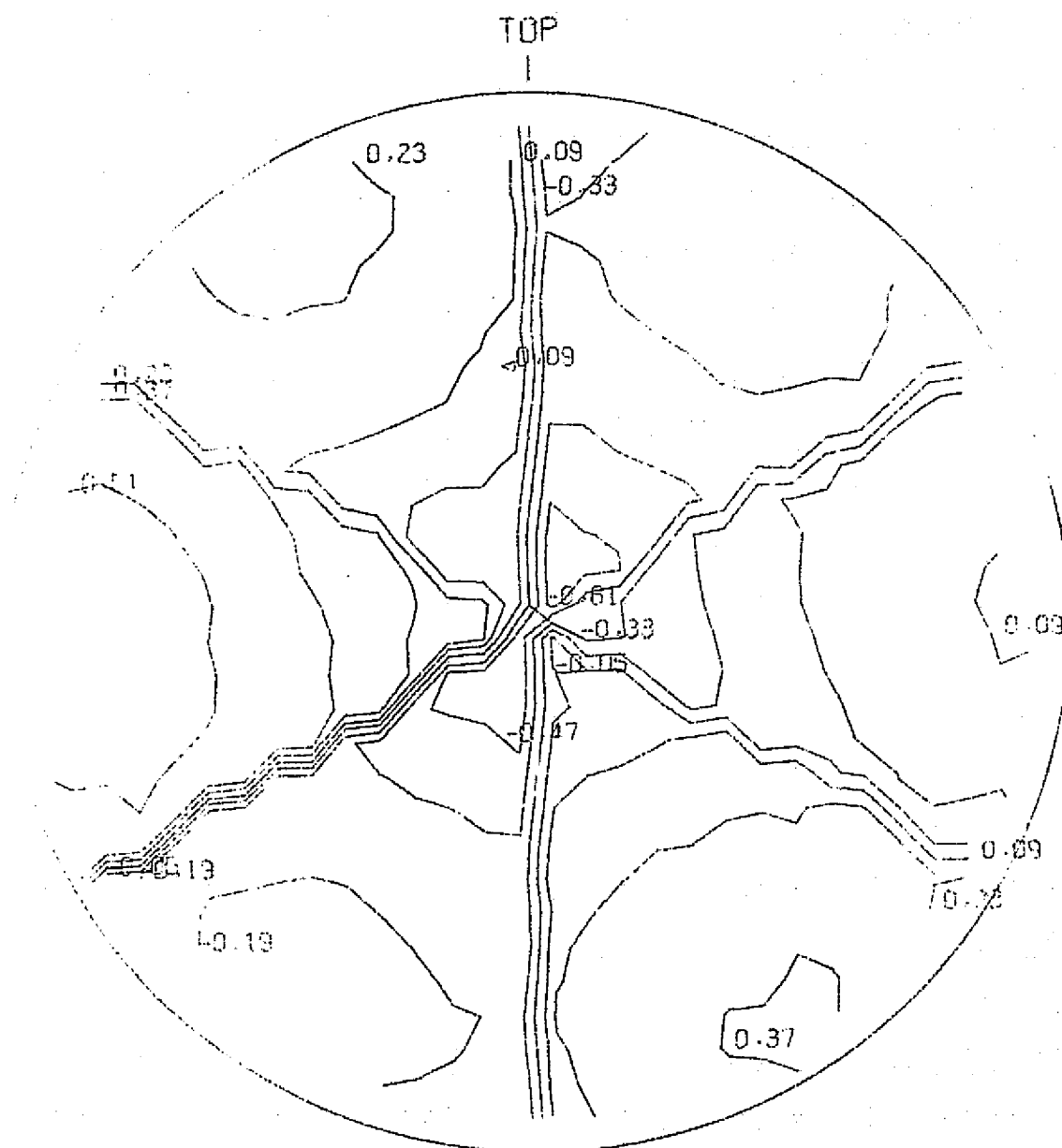


Figure A94

Point Spread Function
Cube #2RW

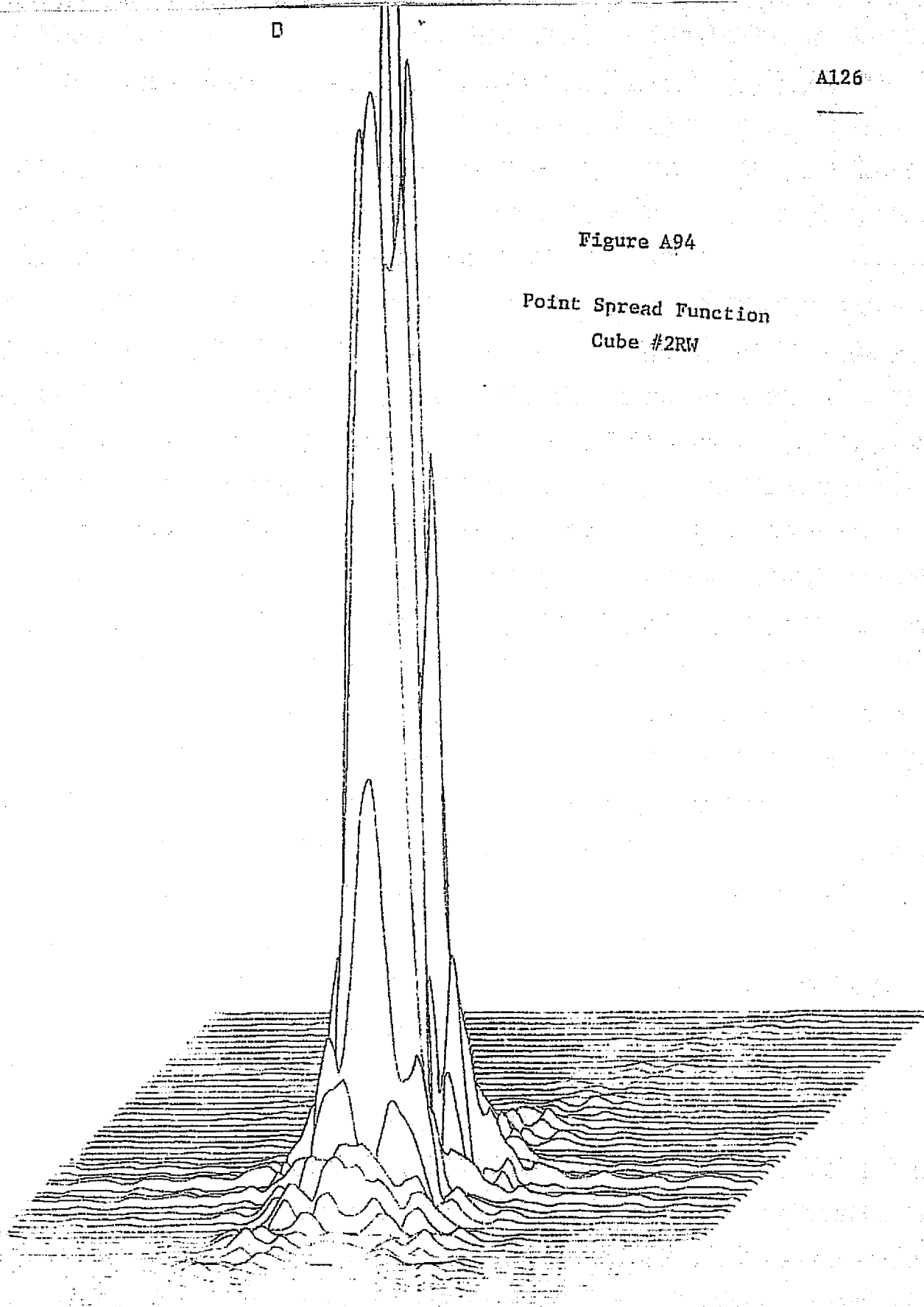


Figure A95

Intensity Distribution - Central 129 Microradians

Cube #2RW

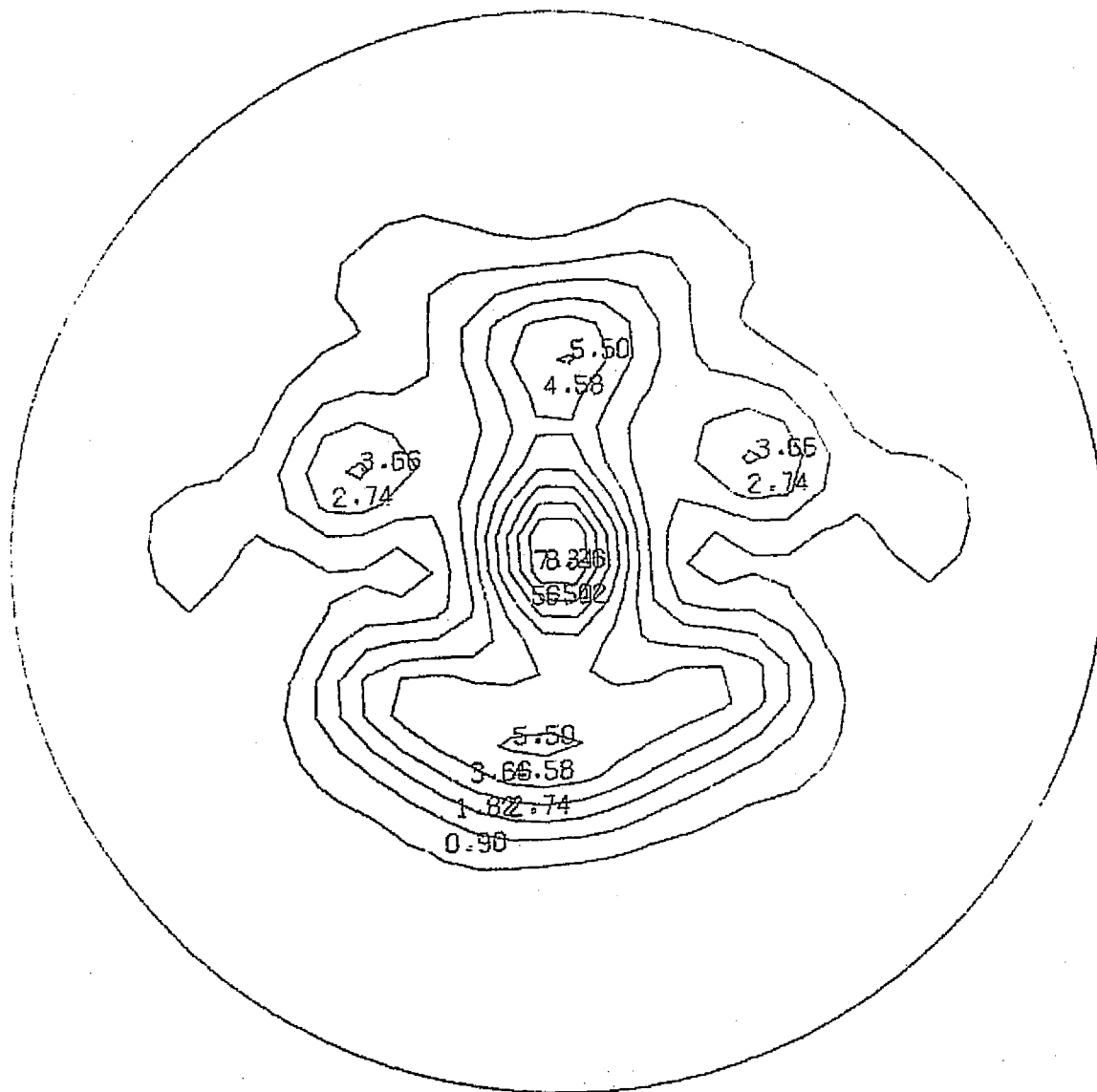
TOP
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Figura A96

Encircled Energy

Vs

Field Angle

Cube #2RW

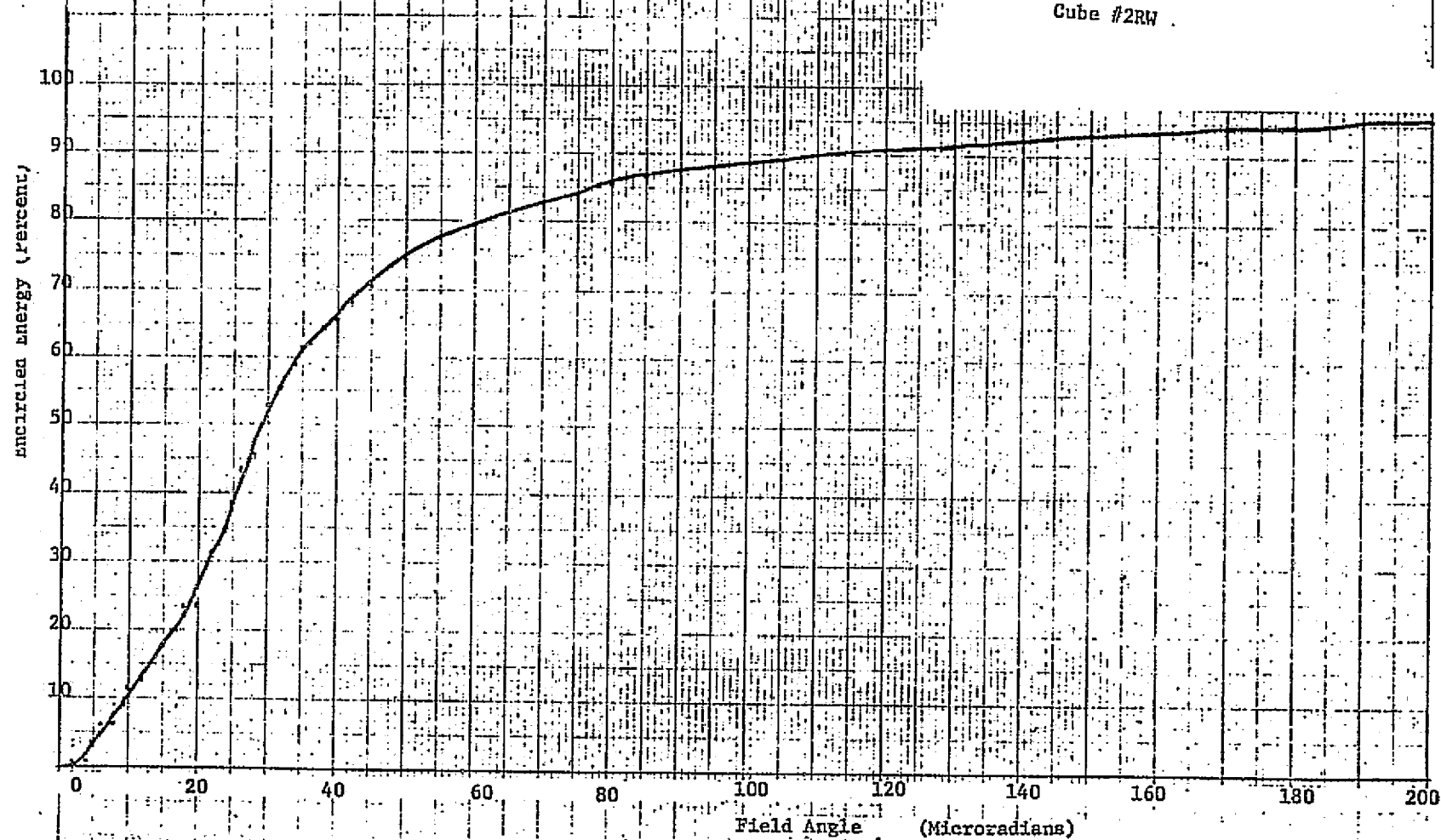


Table A32

ENCIRCLED ENERGY

A129

Cube #2RW

CIRCLE *

* PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

RADIUS *

(MI-
CRONS) *

* CENTER (MICRONS):

* X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 -0.0 10.13 10.13 10.13

*

2.00	*	0.0	0.0	0.4	0.2	0.8	0.2	0.4	0.0	0.0
4.00	*	0.9	0.9	1.0	0.5	0.8	0.5	1.0	1.1	1.2
6.00	*	0.9	0.9	2.9	1.6	6.1	1.6	3.0	1.1	1.2
8.00	*	3.1	3.0	5.6	3.7	6.1	3.7	5.8	3.8	3.9
10.00	*	4.4	4.3	7.0	4.7	11.1	4.7	7.5	5.3	5.4
12.00	*	9.7	9.8	11.2	8.6	12.3	8.6	12.1	11.4	11.4
14.00	*	9.7	9.8	14.1	12.5	15.6	12.5	16.0	11.4	11.4
16.00	*	16.1	16.4	18.1	16.2	17.5	16.2	20.5	18.6	18.3
18.00	*	18.8	19.1	21.0	20.1	23.4	20.2	24.1	21.6	21.4
20.00	*	23.2	23.7	25.7	25.1	23.4	25.1	29.6	26.5	26.0
22.00	*	25.8	26.3	28.9	30.0	31.3	30.1	33.1	29.4	28.9
24.00	*	30.8	31.3	32.0	32.6	35.0	32.7	36.3	34.3	33.8
26.00	*	33.1	33.4	36.0	38.0	43.2	33.1	39.9	36.8	36.4
28.00	*	37.8	38.1	40.6	43.0	45.4	43.1	44.6	40.8	40.6
30.00	*	41.2	41.3	44.4	47.3	52.6	47.3	47.0	44.3	44.2
32.00	*	47.3	47.2	48.6	50.9	55.4	50.9	50.8	49.3	49.4
34.00	*	48.3	48.2	52.4	55.3	59.0	55.3	53.6	50.4	50.5
36.00	*	54.5	54.3	56.9	58.8	61.9	58.7	57.5	55.5	55.6
38.00	*	57.0	56.9	60.0	61.9	64.4	61.8	59.6	57.7	57.7
40.00	*	61.0	60.9	63.5	64.6	65.6	64.6	63.0	61.3	61.3
42.00	*	63.2	63.2	66.1	67.1	68.1	67.0	65.5	63.3	63.2
44.00	*	66.6	66.6	68.0	68.4	69.4	68.3	67.8	66.4	66.3
46.00	*	68.3	68.3	69.9	70.1	71.7	70.1	70.0	68.2	68.1
48.00	*	70.3	70.4	71.6	71.6	72.3	71.5	72.1	70.5	70.3
50.00	*	71.6	71.8	72.8	72.5	74.4	72.5	73.4	72.2	72.0
52.00	*	73.2	73.2	74.0	74.0	75.3	73.9	74.8	73.7	73.5
54.00	*	74.0	74.1	75.3	75.1	76.6	75.0	76.0	74.7	74.5
56.00	*	75.5	75.5	76.5	76.5	77.3	76.5	77.3	76.1	76.0
58.00	*	76.5	76.5	77.4	77.4	78.4	77.4	77.9	77.1	77.1
60.00	*	77.7	77.6	78.4	78.6	79.1	78.5	78.8	78.1	78.1
62.00	*	78.5	78.4	79.2	79.5	79.9	79.4	79.5	78.8	78.8
64.00	*	79.7	79.6	79.9	80.2	80.6	80.2	80.1	79.8	79.9
66.00	*	80.4	80.3	80.8	81.1	81.3	81.1	80.8	80.5	80.5
68.00	*	81.3	81.2	81.4	81.7	81.7	81.7	81.4	81.3	81.4
70.00	*	81.8	81.8	82.2	82.4	82.4	82.3	82.1	81.8	81.9
72.00	*	82.7	82.6	82.7	82.9	83.0	82.9	82.7	82.6	82.7
74.00	*	83.0	83.0	83.4	83.5	83.6	83.5	83.4	83.0	83.1
76.00	*	83.8	83.7	83.9	84.1	84.1	84.1	84.0	83.7	83.8
78.00	*	84.2	84.2	84.4	84.4	84.8	84.4	84.5	84.2	84.3
80.00	*	84.7	84.7	84.9	84.9	85.3	85.0	85.0	84.7	84.8

ENCIRCLED ENERGY

Cube #2RW

CIRCLE *

PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES

RADIUS *

(MICRONS) * CENTER (MICRONS):

* X= -10.13 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13

* Y= -10.13 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13

*

5.00	*	0.9	0.9	2.5	1.6	3.7	1.6	2.6	1.1	1.2
10.00	*	4.4	4.3	7.0	4.7	11.1	4.7	7.5	5.3	5.4
15.00	*	13.6	13.8	17.4	14.7	17.5	14.8	19.3	15.7	15.5
20.00	*	23.2	23.7	25.7	25.1	23.4	25.1	29.6	26.5	26.0
25.00	*	32.3	32.8	35.0	37.4	38.5	37.4	39.3	35.9	35.5
30.00	*	41.2	41.3	44.4	47.3	52.6	47.3	47.0	44.3	44.2
35.00	*	52.5	52.3	54.8	56.6	61.1	56.6	55.4	53.4	53.6
40.00	*	61.0	60.9	63.5	64.6	65.6	64.6	63.0	61.3	61.3
45.00	*	67.5	67.6	69.2	69.5	70.7	69.4	69.0	67.6	67.4
50.00	*	71.6	71.8	72.8	72.5	74.4	72.5	73.4	72.2	72.0
55.00	*	75.0	75.0	75.9	76.0	77.2	75.9	76.6	75.5	75.4
60.00	*	77.7	77.6	78.4	78.6	79.1	78.5	78.8	78.1	78.1
65.00	*	80.0	79.9	80.5	80.7	81.0	80.7	80.5	80.1	80.2
70.00	*	81.8	81.8	82.2	82.4	82.4	82.3	82.1	81.8	81.9
75.00	*	83.5	83.5	83.7	83.8	83.9	83.8	83.7	83.4	83.5
80.00	*	84.7	84.7	84.9	84.9	85.3	85.0	85.0	84.7	84.8
85.00	*	85.7	85.7	86.1	86.1	86.5	86.1	86.3	85.8	85.9
90.00	*	86.7	86.7	87.0	87.0	87.3	87.0	87.1	86.8	86.9
95.00	*	87.7	87.7	87.8	87.8	87.9	87.8	87.8	87.8	87.8
100.00	*	88.4	88.4	88.4	88.5	88.5	88.5	88.5	88.5	88.5
105.00	*	89.0	89.0	89.1	89.1	89.1	89.1	89.2	89.0	89.1
110.00	*	89.6	89.6	89.7	89.7	89.8	89.7	89.8	89.6	89.7
115.00	*	90.2	90.2	90.2	90.2	90.4	90.2	90.3	90.2	90.2
120.00	*	90.7	90.7	90.8	90.8	90.9	90.8	90.8	90.7	90.7
125.00	*	91.1	91.1	91.3	91.2	91.3	91.2	91.2	91.1	91.1
130.00	*	91.6	91.5	91.6	91.6	91.6	91.6	91.6	91.5	91.5
135.00	*	91.9	91.9	91.9	91.9	91.9	91.9	91.9	91.9	91.9
140.00	*	92.3	92.3	92.3	92.3	92.2	92.3	92.2	92.2	92.3
145.00	*	92.7	92.7	92.7	92.7	92.5	92.7	92.6	92.6	92.6
150.00	*	93.0	93.0	93.1	93.0	93.1	93.0	93.0	93.0	93.0
155.00	*	93.3	93.3	93.4	93.3	93.5	93.3	93.4	93.3	93.3
160.00	*	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7
165.00	*	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0
170.00	*	94.2	94.3	94.3	94.3	94.3	94.3	94.3	94.3	94.3
175.00	*	94.5	94.5	94.5	94.6	94.5	94.6	94.5	94.5	94.5
180.00	*	94.8	94.8	94.9	94.9	94.9	94.9	94.8	94.8	94.8
184.99	*	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1
189.99	*	95.4	95.4	95.4	95.4	95.4	95.3	95.4	95.4	95.4
194.99	*	95.6	95.6	95.7	95.6	95.7	95.6	95.7	95.6	95.6
199.99	*	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9

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Figure A27

Wavefront Map ~ Q Polarization

Case #384

MAP IN UNITS OF 0.01 WAVES

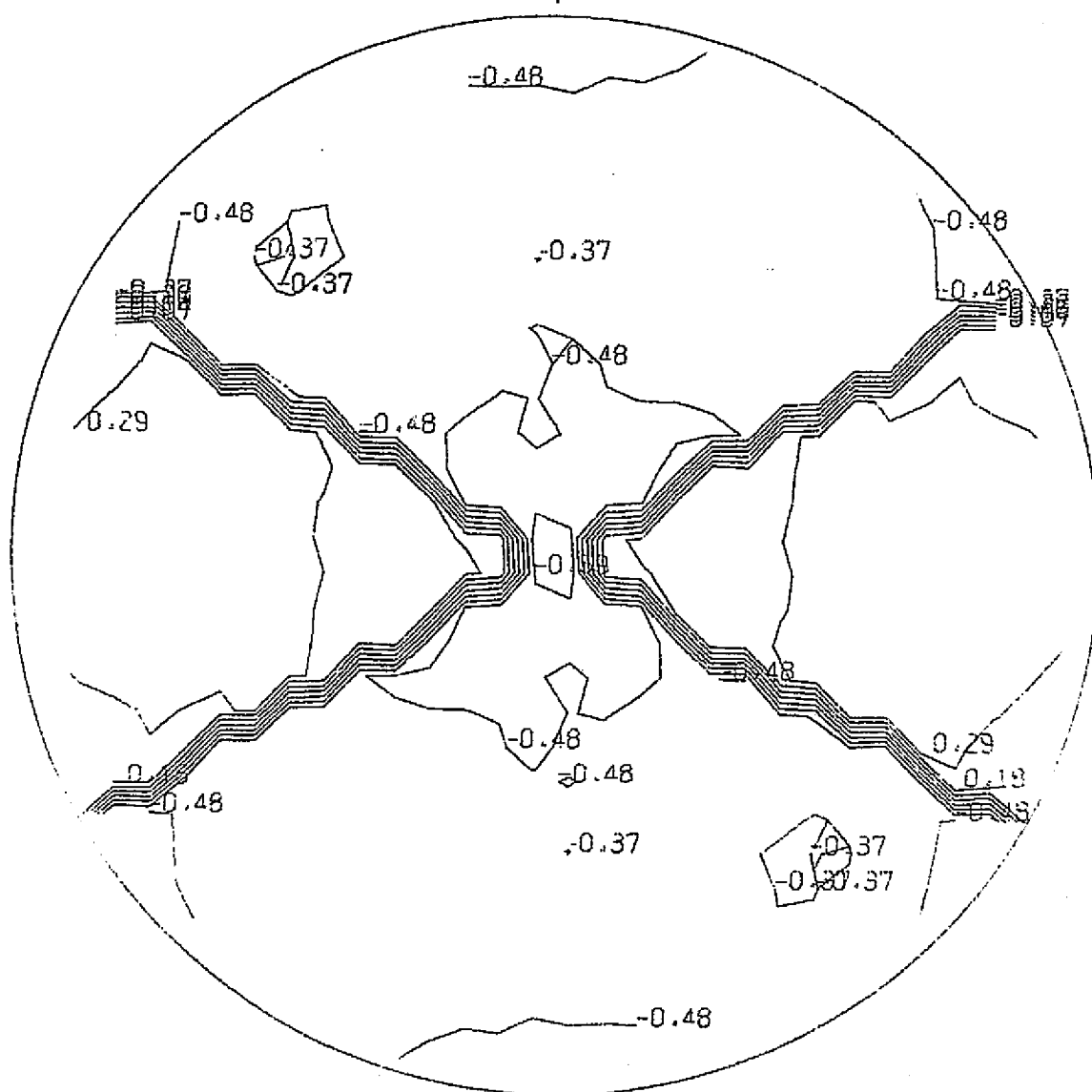
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Figure A98

Wavefront Plot - Q Polarization

Cube #3RW

TOP
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Figure A99

A133

Wavefront Map - P Polarization

Cube #3RW

MAP IN UNITS OF 0.01 WAVES

14 9 5 4 4 -45 -43 -43 -42 -38
15 15 14 15 12 10 10 10 -40 -38 -38 -36 -36 -34 -33 -33
14 17 18 18 16 16 15 15 15 -34 -35 -34 -33 -33 -31 -31 -31 -32
16 17 20 20 21 20 19 19 17 13 -34 -32 -32 -32 -31 -31 -31 -31 -32 -36
10 18 19 21 21 20 20 19 20 18 18 -36 -33 -31 -32 -31 -31 -32 -31 -32 -36 -40
5 11 16 21 21 21 20 19 19 19 18 16 -31 -32 -31 -31 -30 -32 -32 -31 -31 -35 -38 -42
0 6 13 18 21 21 22 20 19 19 18 16 -21 -32 -33 -32 -32 -32 -33 -33 -32 -32 -34 -37 -45 -47
24 4 7 14 17 20 21 20 20 19 18 17 15 15 -33 -34 -34 -34 -34 -33 -32 -32 -33 -33 -37 -44 -50 -18
31 36 43 12 15 16 15 15 19 18 17 14 13 9 -37 -36 -36 -36 -35 -34 -33 -34 -35 -34 -31 -8 -6 -14
36 41 46 47 11 15 18 18 18 17 15 14 13 14 -44 -38 -38 -38 -36 -36 -36 -36 -38 -38 -7 -5 -9 -12
37 42 45 48 50 47 45 22 15 15 14 13 12 9 10 -43 -40 -39 -39 -38 -37 -38 -33 -3 -6 -5 -3 -6 -9 -11
42 45 47 51 51 45 46 45 43 10 10 11 8 7 13 -41 -43 -42 -41 -41 -38 -6 -3 -3 -3 -2 -1 -1 -3 -8
45 47 50 51 52 51 48 46 46 40 39 12 8 4 5 -46 -44 -43 -35 -7 -12 -5 -4 -3 -1 -1 0 0 -1 -4
45 47 51 51 51 50 45 47 44 42 40 41 6 1 2 -46 -44 -40 -8 -7 -7 -5 -3 -2 -1 0 0 0 -1 -1
47 48 50 51 50 45 48 47 44 43 39 36 32 28 -7 -52 -19 -13 -13 -10 -8 -4 -3 -1 0 0 1 0 0 -1
48 49 50 51 50 49 48 46 44 41 39 36 36 30 -40 3 -21 -17 -13 -10 -6 -5 -2 -1 0 0 1 0 -1 -2
47 48 50 45 45 48 47 46 44 42 41 41 -28 -32 -34 14 13 17 -8 -9 -7 -5 -2 0 0 1 1 1 -2 -4
45 48 49 45 48 48 46 45 44 37 42 -23 -32 -33 -35 17 15 20 23 -10 -9 -3 -3 -1 1 2 2 0 -2 -4
41 46 48 48 47 46 46 46 43 -27 -29 -29 -30 -31 -29 25 19 20 23 22 21 -6 0 -3 0 1 1 -2 -4 -7
38 40 43 46 44 43 46 -22 -26 -25 -26 -27 -27 -28 -31 22 21 24 25 26 27 31 33 0 -2 0 -1 -4 -7 -12
37 40 44 42 -26 -27 -24 -24 -24 -24 -26 -26 -26 -33 26 24 26 27 29 29 30 30 26 23 -2 -3 -8 -13
35 43 41 -20 -23 -23 -22 -21 -22 -24 -24 -25 -24 -25 21 25 26 28 30 30 30 31 30 27 24 -6 -13 -18
31 -38 -32 -25 -21 -22 -21 -21 -22 -22 -23 -22 -22 -21 27 27 28 30 31 32 32 33 32 29 26 19 16 -25
-35 -33 -25 -22 -21 -21 -21 -21 -20 -21 -21 -22 -21 33 27 30 30 31 32 33 33 33 30 25 18 12
-30 -27 -23 -19 -20 -20 -20 -19 -19 -19 -20 -19 27 29 31 31 31 31 33 33 32 28 23
-29 -24 -20 -19 -20 -19 -19 -20 -20 -21 -25 30 29 31 31 32 32 33 33 31 29 21
-24 -21 -20 -19 -19 -19 -20 -21 -21 -22 25 29 30 31 32 32 32 31 29 28
-21 -19 -19 -20 -21 -22 -22 -23 -23 27 26 26 28 28 29 30 29 26
-22 -21 -22 -24 -24 -27 -26 -29 22 21 22 24 26 26 27 27
-27 -30 -32 -32 -33 16 16 17 20 25

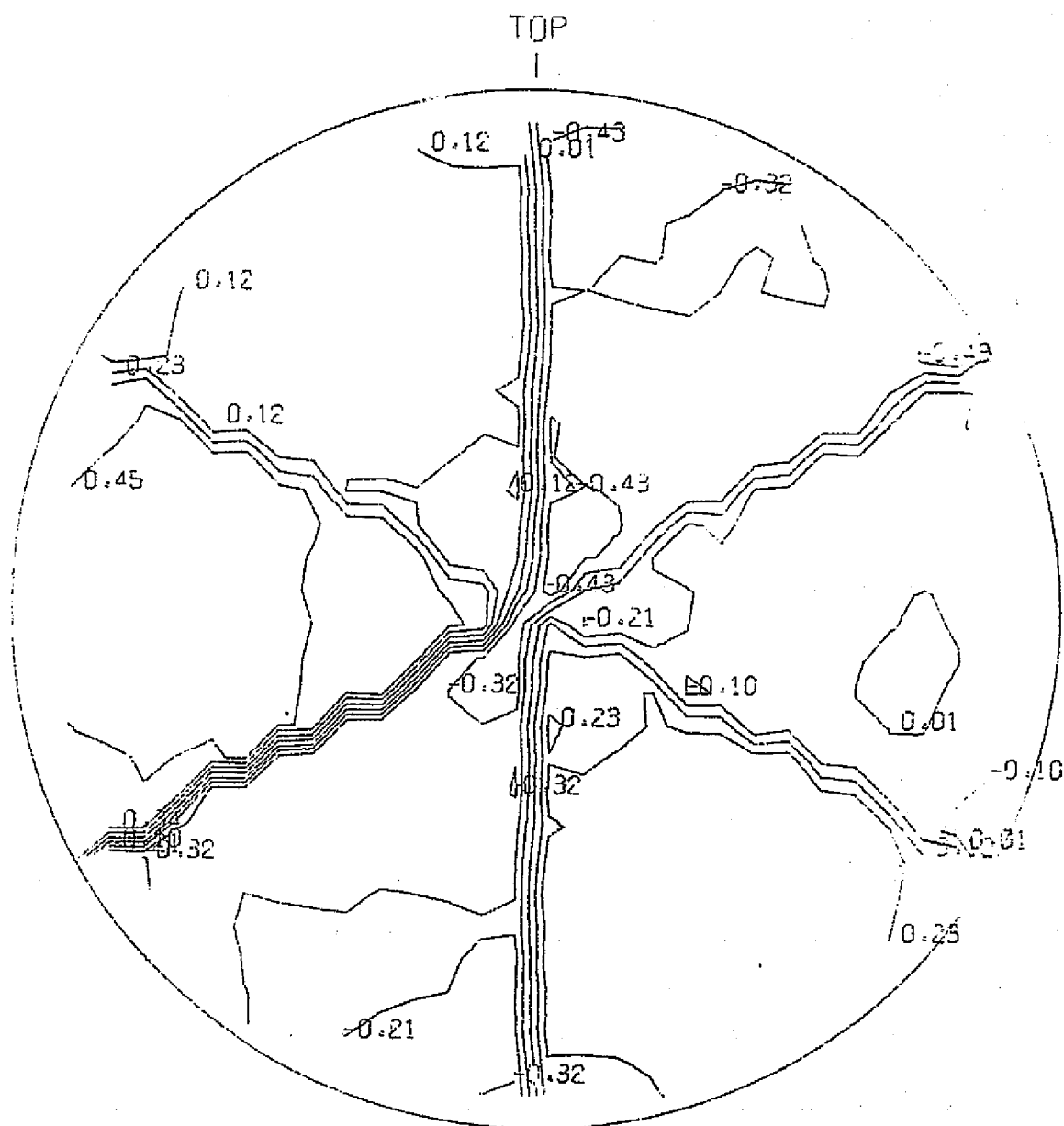
3.755

0.01 WAVE

Wavefront Plot - P Polarization

- Cube #3RW

TOP



A135

Cube #3RW

NORMALIZED SO LARGEST VALLE = 0.1041 * 100

TOTAL ENERGY = 0.2461000D+01

MAP REPRESENTS C.23C6564D+01 OR 93.7409 PERCENT CF TCTAL ENERGY

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Figure A102

Point Spread Function

Cube #3RW

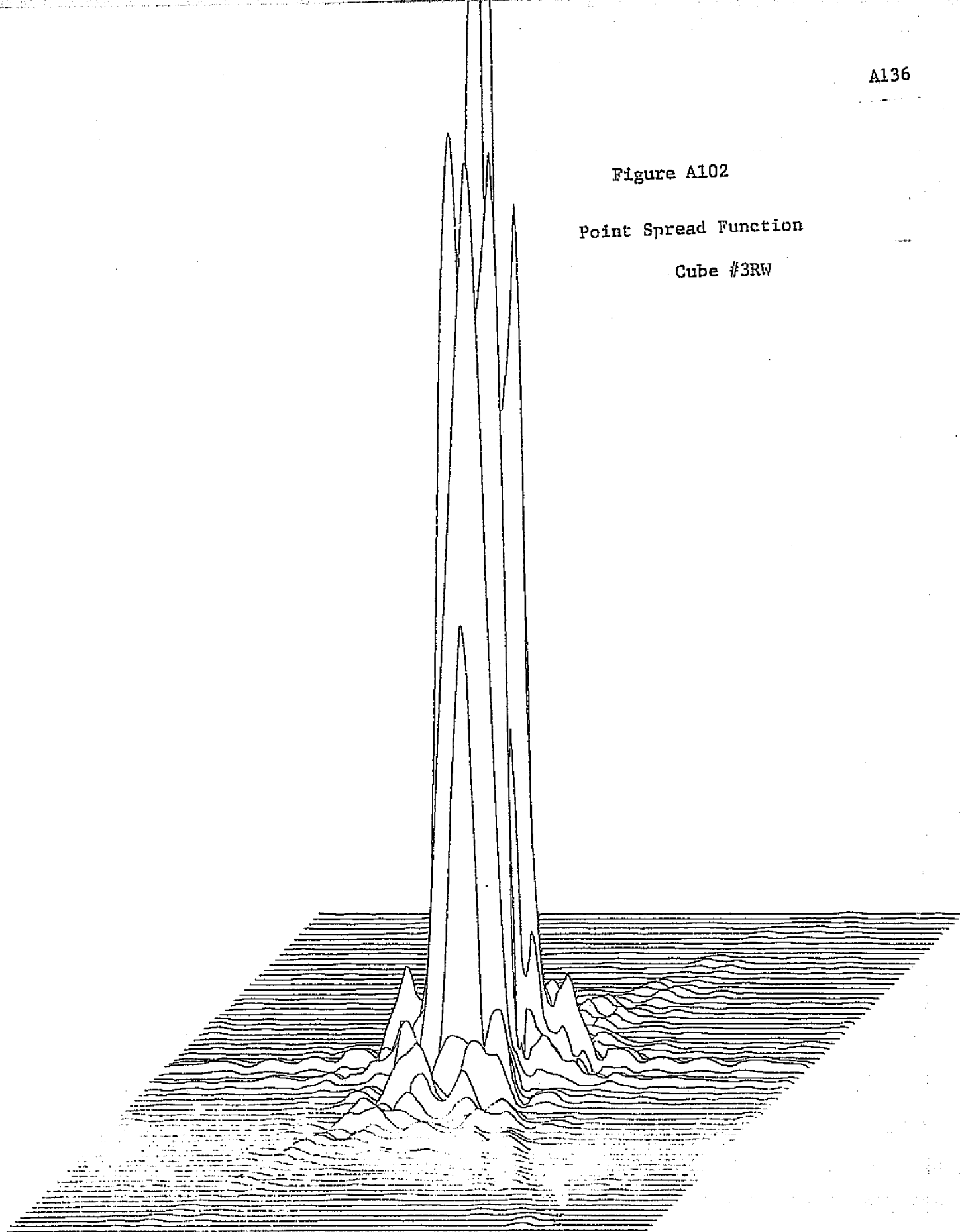
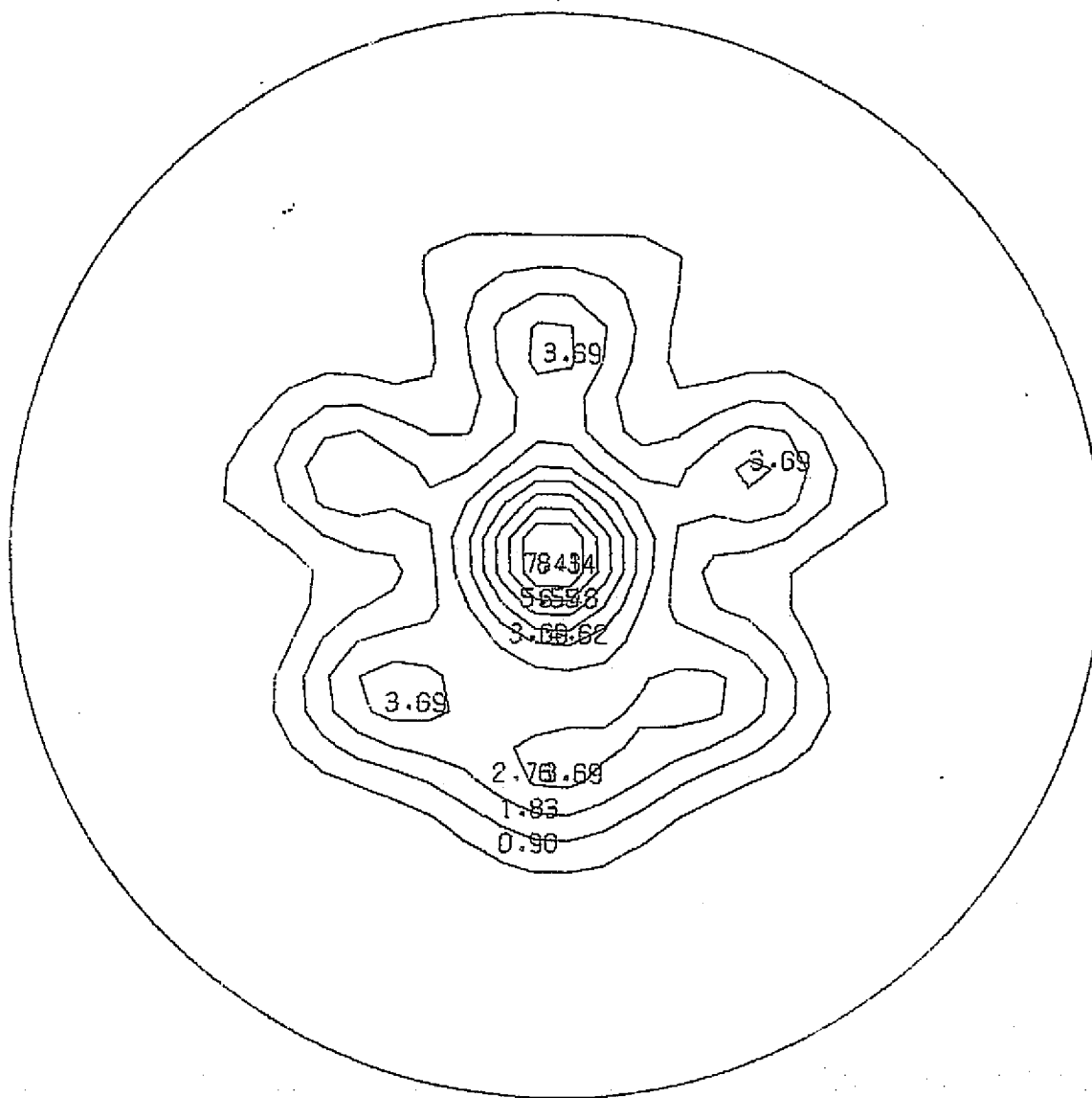


Figure A103

Intensity Distribution - Central 129 Microradians

Cube #3RW

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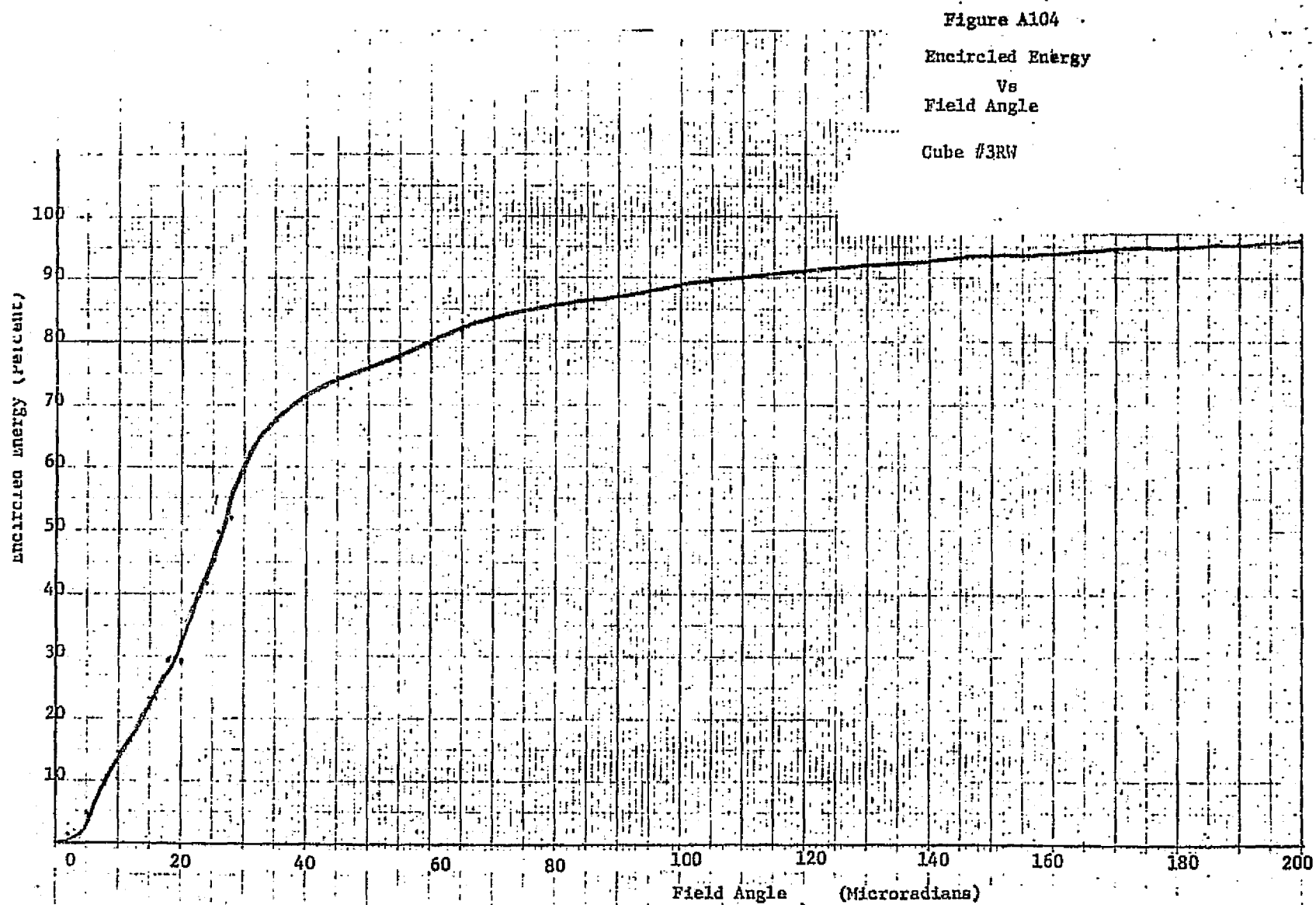


Table A34

A139

ENCIRCLED ENERGY

Cube #3RW

CIRCLE *
 ----- * PERCENT ENERGY WITHIN CIRCLE CENTERED AT INDICATED COORDINATES
 RADIUS *
 ----- *

{MI- * CENTER (MICRONS):
 CRONS) * X= -10.12 10.13 0.0 -10.13 0.0 10.13 0.0 -10.13 10.13
 * Y= -10.12 -10.13 -10.13 0.0 0.0 0.0 10.13 10.13 10.13
 *

2.00	*	0.0	0.0	0.4	0.4	1.1	0.4	0.4	0.0	0.0
4.00	*	1.2	1.1	1.1	1.0	1.1	1.0	1.1	1.4	1.5
6.00	*	1.2	1.1	3.2	2.9	7.8	2.9	3.3	1.4	1.5
8.00	*	3.9	3.7	6.2	5.9	7.8	5.8	6.5	4.6	4.8
10.00	*	5.4	5.2	7.8	7.4	14.6	7.4	8.4	6.4	6.5
12.00	*	11.7	11.5	12.8	12.4	16.2	12.4	13.8	13.4	13.6
14.00	*	11.7	11.5	16.4	16.9	20.6	16.9	18.6	13.4	13.6
16.00	*	19.2	19.2	21.0	21.5	23.0	21.5	23.8	21.7	21.8
18.00	*	22.2	22.3	24.6	25.5	29.7	25.5	28.2	25.3	25.3
20.00	*	27.3	27.5	30.1	31.4	29.7	31.4	34.6	30.8	30.6
22.00	*	30.4	30.6	33.9	35.9	37.9	35.9	39.0	34.3	34.1
24.00	*	36.0	36.2	37.3	39.2	41.5	39.2	42.5	39.9	39.7
26.00	*	38.4	38.6	41.9	44.1	49.7	44.1	46.8	42.7	42.5
28.00	*	43.3	43.6	46.5	49.3	51.9	49.3	51.7	47.0	46.8
30.00	*	46.8	46.9	50.8	53.1	59.1	53.1	54.3	50.7	50.6
32.00	*	52.7	52.8	54.6	56.8	61.8	56.8	57.7	55.4	55.4
34.00	*	53.7	53.7	58.7	60.6	65.6	60.7	60.5	56.4	56.5
36.00	*	59.6	59.5	62.8	63.9	68.1	63.9	63.8	60.9	61.0
38.00	*	62.0	61.8	65.7	66.9	70.3	66.9	65.2	62.7	62.8
40.00	*	65.6	65.4	68.9	69.2	71.3	69.2	68.0	65.7	65.9
42.00	*	67.7	67.5	71.0	71.2	73.0	71.2	69.7	67.3	67.5
44.00	*	70.8	70.6	72.5	72.5	73.6	72.5	71.5	69.9	70.1
46.00	*	72.2	72.0	73.8	73.6	74.8	73.6	72.9	71.3	71.5
48.00	*	74.0	73.8	75.0	74.7	75.0	74.7	74.5	73.3	73.5
50.00	*	75.0	74.9	75.6	75.2	75.9	75.2	75.4	74.6	74.8
52.00	*	76.2	76.1	76.3	76.3	76.4	76.3	76.4	75.9	76.0
54.00	*	76.7	76.6	77.1	76.9	77.1	76.9	77.4	76.7	76.8
56.00	*	77.7	77.6	77.8	77.9	77.6	77.9	78.4	77.9	77.9
58.00	*	78.2	78.2	78.4	78.4	78.6	78.4	79.0	78.7	78.7
60.00	*	79.0	79.0	79.0	79.3	79.4	79.3	79.7	79.5	79.4
62.00	*	79.5	79.5	79.9	80.0	80.3	80.0	80.5	80.0	79.9
64.00	*	80.4	80.4	80.4	80.7	81.2	80.7	80.9	80.9	80.8
66.00	*	80.9	80.9	81.4	81.5	82.2	81.5	81.7	81.3	81.2
68.00	*	81.7	81.8	81.9	82.2	82.6	82.2	82.2	82.0	81.9
70.00	*	82.2	82.2	82.8	82.9	83.4	82.9	82.8	82.5	82.3
72.00	*	83.0	83.1	83.3	83.5	83.9	83.5	83.3	83.2	83.1
74.00	*	83.4	83.5	84.1	84.1	84.5	84.1	83.9	83.5	83.4
76.00	*	84.2	84.3	84.6	84.7	84.8	84.6	84.4	84.2	84.1
78.00	*	84.6	84.7	85.1	85.0	85.3	84.9	84.8	84.6	84.5
80.00	*	85.2	85.3	85.5	85.4	85.6	85.4	85.3	85.1	85.0

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Cube #3RW

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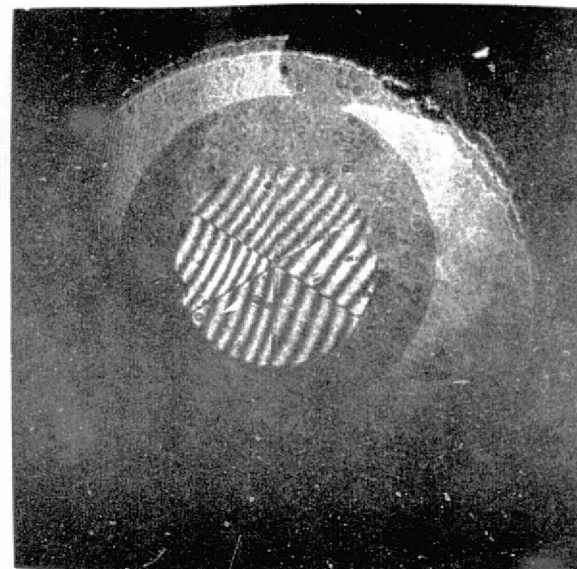
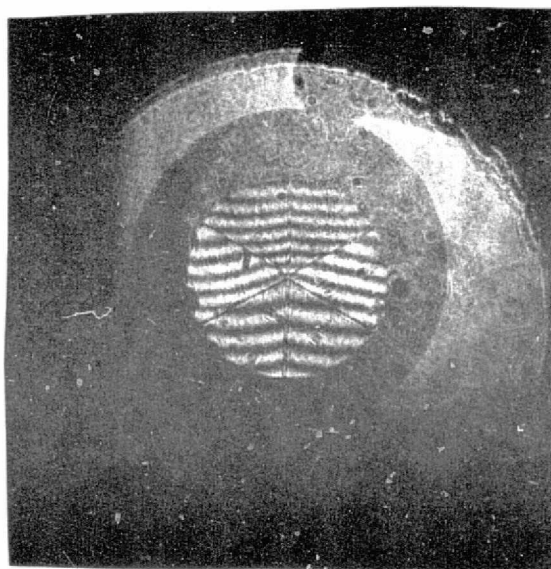
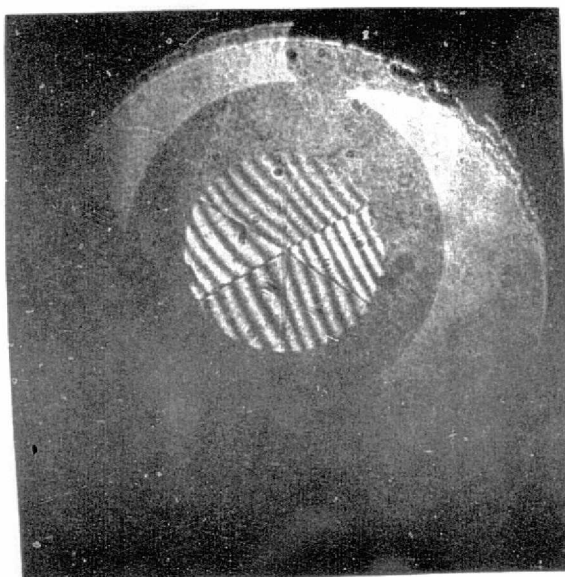
APPENDIX B

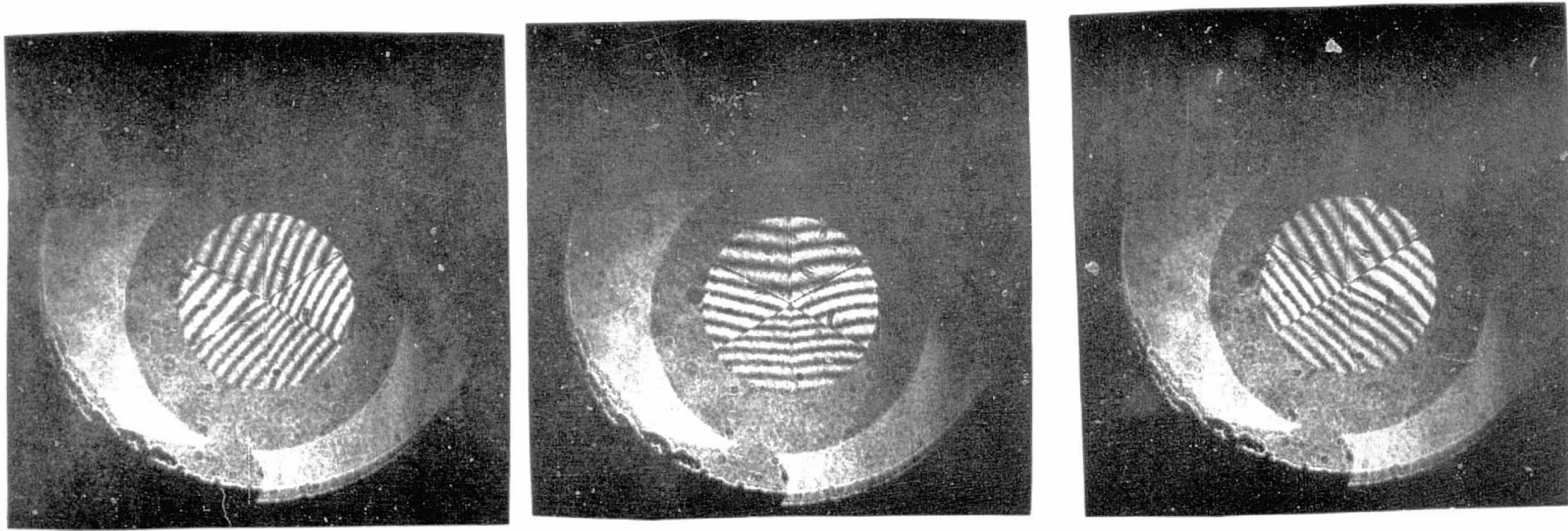
Cube Interferograms

The interferograms taken by Itek for use in determination of the dihedral angles and the far field patterns of the six initial cube corner retroreflectors are shown in Figures B1 - B6. The interferograms taken by ZYGO of the three reworked cubes for use in the Itek analysis are shown in Figures B7 - B9.

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FIGURE B1
INTERFEROGRAMS OF CUBE NUMBER 1





INTERFEROGRAMS OF CUBE NUMBER 2

FIGURE B2

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FIGURE B3
INTERFEROGRAMS OF CUBE NUMBER 3

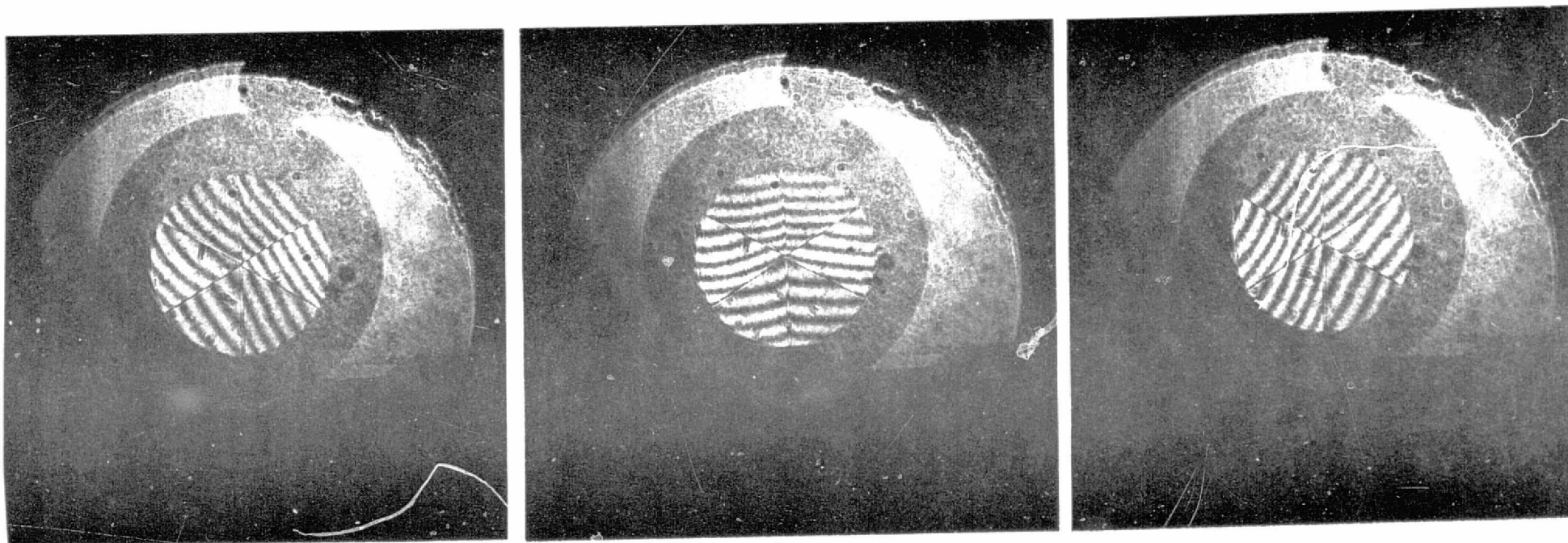
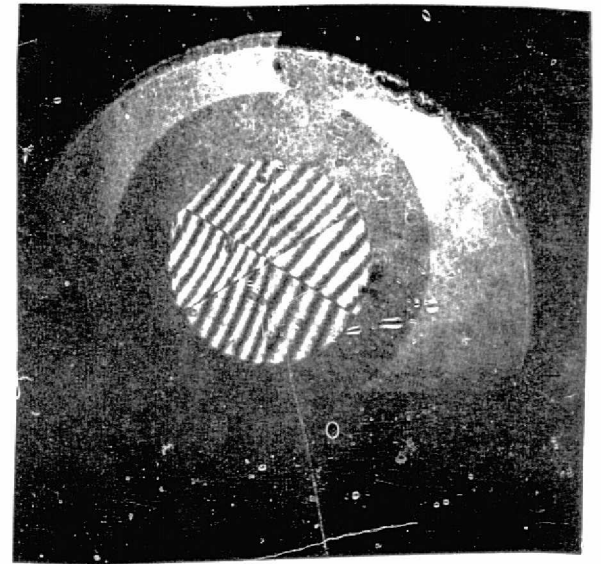
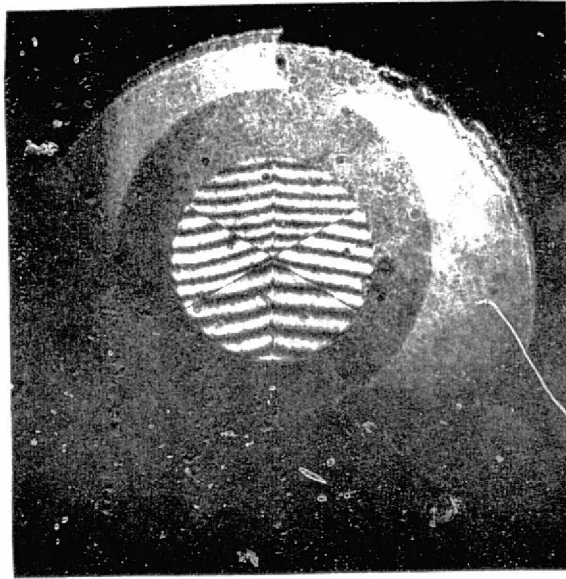
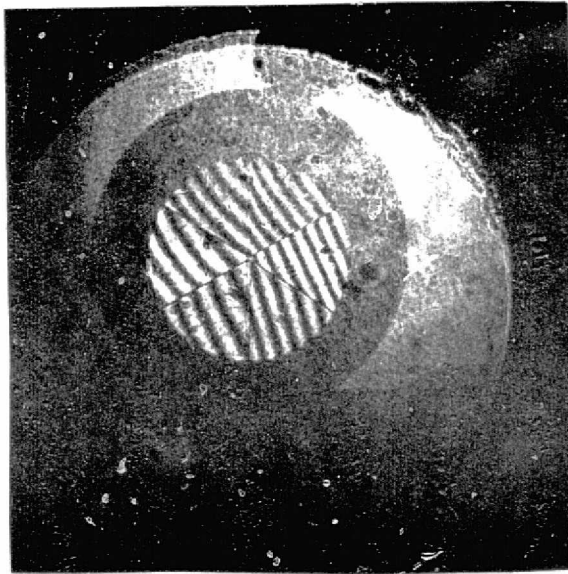


FIGURE B4
INTERFEROGRAMS OF CUBE NUMBER 4



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FIGURE B5
INTERFEROGRAMS OF CUBE NUMBER 5

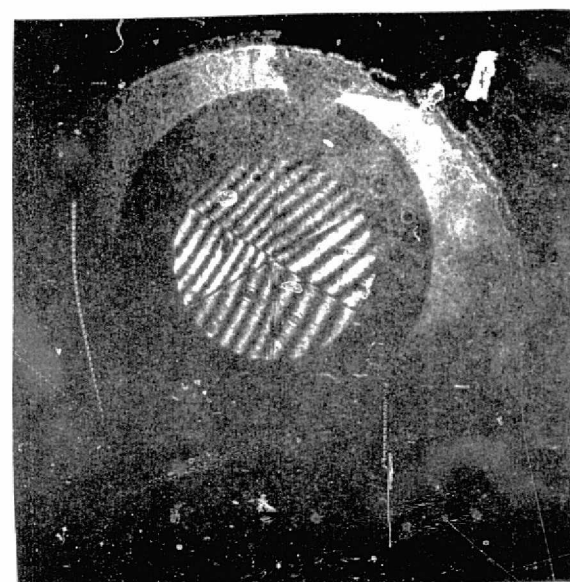
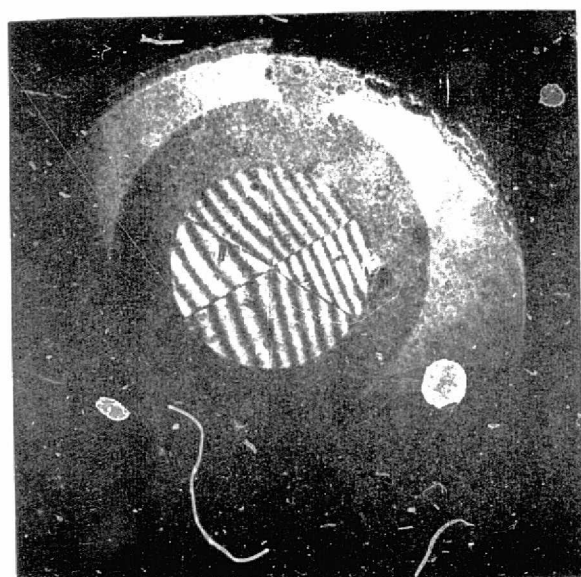
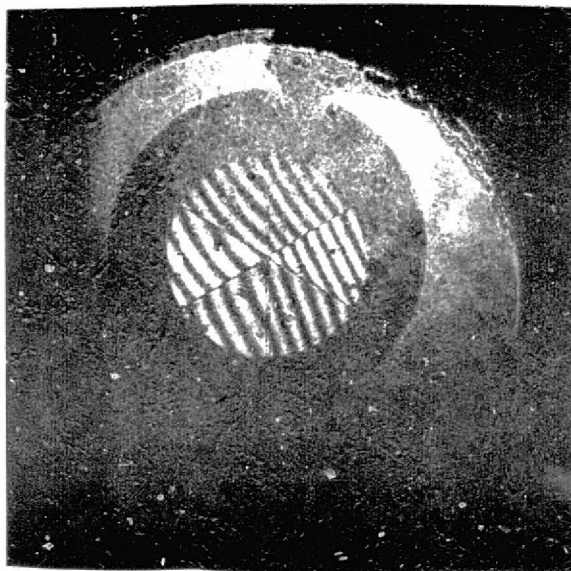


FIGURE B6
INTERFEROGRAMS OF TUBE NUMBER 6



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FIGURE B7
ZYGO INTERFEROGRAMS OF CUBE NUMBER 1RW

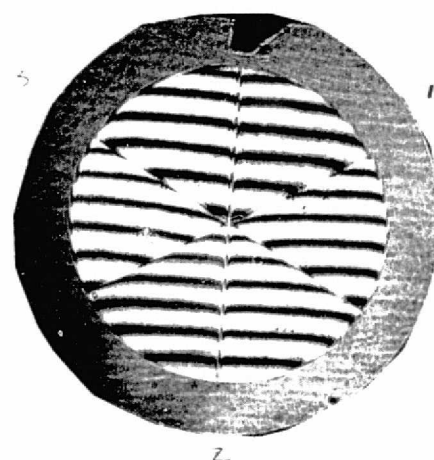
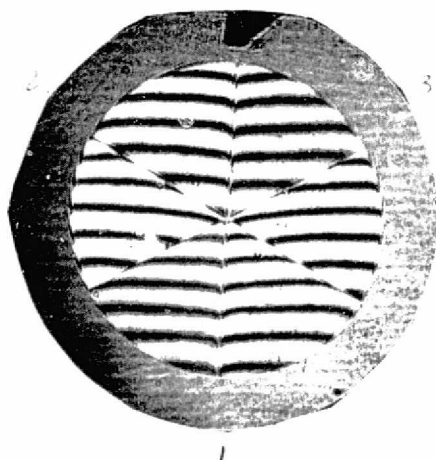
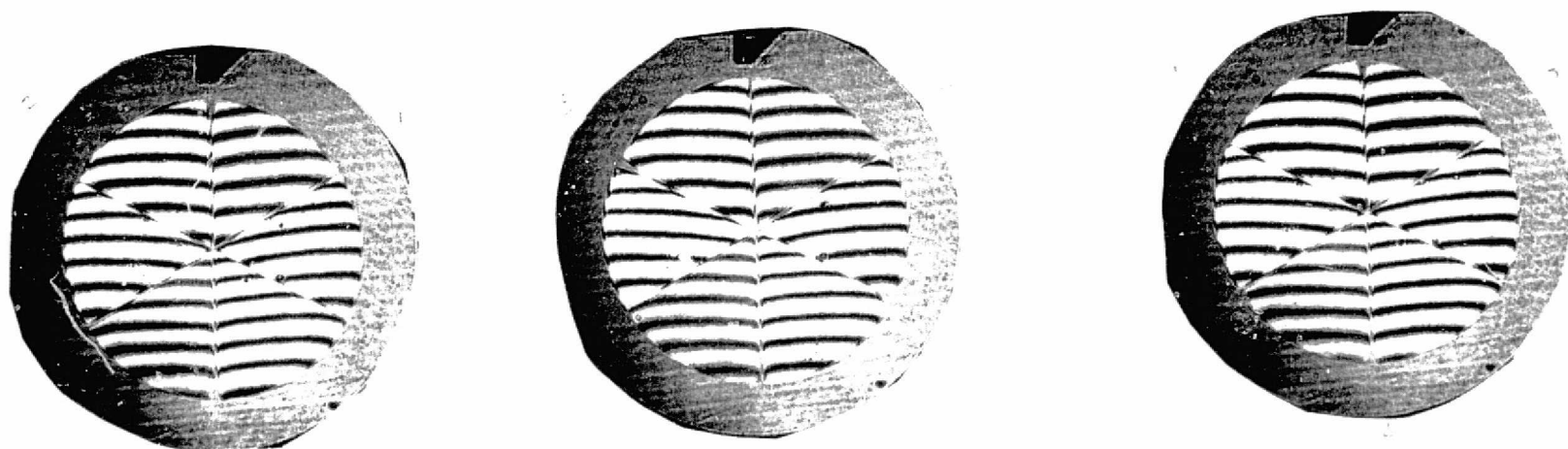


FIGURE B8
ZYGO INTERFEROGRAMS OF CUBE NUMBER 2RW



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FIGURE B9
ZYGO INTERFEROGRAMS OF CUBE NUMBER 3RW



APPENDIX C

Dihedral Angle Calculations

When a ray is incident on the front face of a perfect retroreflector (90° cube corner) it is consecutively reflected by the three reflecting surfaces and leaves the reflector in a direction parallel to the incoming ray at a point diametrically opposite to its point of entry. When the angles are not perfect 90° angles the ray will be deviated and will not exit parallel to the incoming ray. This study is intended to obtain the deviation of the angles of the cube corner from a 90° corner by examining the wavefront exiting the cube.

In figure C.1 δ_{mn} is defined as the angular deviation of surface m at a point adjacent to surface number n due to a rotation of surface m about the axis perpendicular to surface n . As an example δ_{12} is the angular deviation of surface number 1 at a point adjacent to surface number 2 due to a rotation of surface 1 about the x axis. The deviations of the angles of the cube from a perfect 90° are referred to as the dihedral angles and are determined by

$$\alpha_{12} = \delta_{13} + \delta_{23} \quad C\ 1$$

$$\alpha_{23} = \delta_{31} + \delta_{21} \quad C\ 2$$

$$\alpha_{13} = \delta_{12} + \delta_{32} \quad C\ 3$$

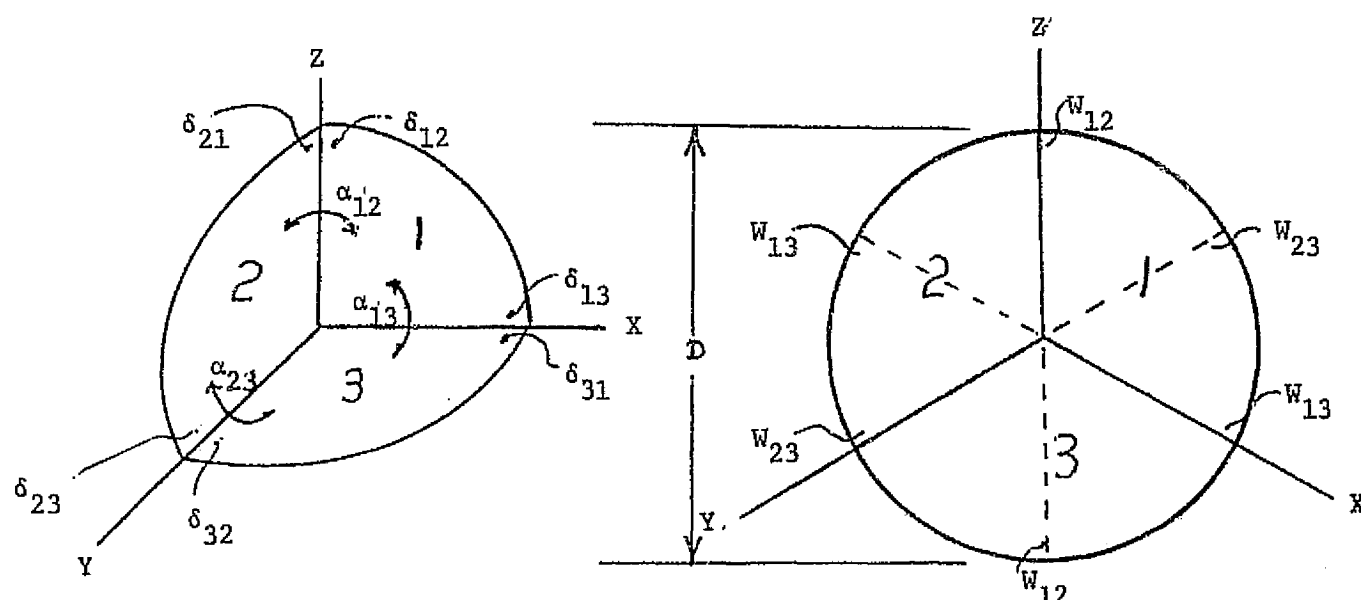


Figure C-1
Cube Coordinate System

In general, the optical path difference (OPD) introduced by a small perturbation to a reflecting surface is given by¹

$$\text{OPD} = 2N S \cos \theta$$

where N is the index of refraction of the material, S is the deviation of the surface from nominal measured normal to the surface, and θ is the angle of incidence of the ray at the surface. For the axial beam, the angle of incidence at each surface is the same and has the value defined by $\cos \theta = 1/\sqrt{3}$.²

Referring to figure C-1, it can be seen that the surface deviation at any point on a surface is equal to the angular deviation multiplied by the distance of that point from the center of the cube. For example, in calculating W_{12} , the ray strikes surfaces 1 and 2 at the real edge and surface 3 at the center of the surface. The distance from the center along the real edge is $D/(2 \sin \theta)$ and the distance from the center to the ray on surface 3 is $D/(2 \cos \theta)$. Thus,

$$W_{12} = 2 \left(\frac{D}{2 \cos \theta} \left(\frac{\delta_{31} + \delta_{32}}{\sqrt{2}} \right) + \frac{D \delta_{21}}{2 \sin \theta} + \frac{D \delta_{12}}{2 \sin \theta} \right) N \cos \theta \quad \text{C5}$$

$$\text{where } \cos \theta = \frac{1}{\sqrt{3}}$$

$$\sin \theta = \sqrt{\frac{2}{3}}$$

$$\therefore W_{12} = \frac{ND}{\sqrt{2}} (\delta_{31} + \delta_{32} + \delta_{21} + \delta_{12}). \quad \text{C6}$$

Using equations C2 and C3.

$$W_{12} = \frac{ND}{\sqrt{2}} (\alpha_{23} + \alpha_{13}) \quad \text{C7}$$

¹ M.P. Rimmer, App. Opt. 9, 533 (1970)

² E.R. Peck, J. Opt. Soc Am. 52, 253 (1962)

In the same manner W_{13} and W_{23} is given by

$$W_{13} = \frac{ND}{\sqrt{2}} (\alpha_{12} + \alpha_{23}) \quad C8$$

$$W_{23} = \frac{ND}{\sqrt{2}} (\alpha_{12} + \alpha_{13}) \quad C9$$

Using equations C6, C7, and C8 the dihedral angles can be solved for

$$\alpha_{13} = \frac{1}{\sqrt{2} ND} (W_{12} + W_{23} - W_{13}) \quad C10$$

$$\alpha_{23} = \frac{1}{\sqrt{2} ND} (W_{12} + W_{13} - W_{23}) \quad C11$$

$$\alpha_{12} = \frac{1}{\sqrt{2} ND} (W_{13} + W_{23} - W_{12}) \quad C12$$

Another useful quantity is the angle between the exiting rays and the incoming rays. This can be determined from the values of W_{12} , W_{13} , and W_{23} using the fact that the rays are normal to the wavefront in each sextant. The result for the sextant between W_{12} and W_{23} is

$$\sin \phi = \frac{4}{\sqrt{3} D} \sqrt{W_{12}^2 + W_{23}^2 - W_{12} W_{23}} \quad C13$$

where ϕ is the angle between the entering rays and exiting rays. The angle between rays exiting from two opposite sextants is 2ϕ . Similar results are obtained for the other sextants. Equation C13 can be written in terms of the dihedral angles by substituting equations C7 - C9. When all of the dihedral angles are equal, it can be seen that

$$\sin \phi = 4N\sqrt{\frac{2}{3}} \alpha \quad C14$$

where α is the dihedral angle error. This result is in agreement with Yoder.³

³ P.R. Yoder, Jr. J. Opt. Soc. Am. 48, 496 (1958)

APPENDIX D

Viewgraph Presentation

Copies of the viewgraphs presented at a briefing at George C. Marshall Space Flight Center, Huntsville, Alabama on 24 October, 1974 are given on pages D2 - D29. Copies of the viewgraphs presented at a briefing at NASA/MSFC on 18 December are given on pages D30 - D52.

LAGEOS
DIHEDRAL ANGLE IMPROVEMENT PROGRAM
PREPARED UNDER
CONTRACT TO
BENDIX AEROSPACE SYSTEMS DIVISION
24 OCTOBER 1974



TOPICS

- PURPOSE/OBJECTIVES
- TASKS
- SUMMARY OF RESULTS
- INTERFEROMETRY OF CUBES
- PREDICTION OF DIHEDRAL ANGLES
- PREDICTION OF FAR FIELD PATTERN
- TOLERANCE ANALYSIS
- CONCLUSIONS

PURPOSE/OBJECTIVES

RESOLVE CONTRADICTIONS IN TEST RESULTS

- PREDICT DIHEDRAL ANGLES FROM INTERFEROGRAMS
COMPARE WITH INDEPENDENT MEASUREMENTS
- PREDICT FAR FIELD PATTERN FROM INTERFEROGRAMS
COMPARE WITH MEASURED DATA
- RECOMMEND REVISED DIHEDRAL ANGLE
- ANALYZE REWORKED CUBES

TASKS

- EVALUATE EXISTING CUBES
 - ANALYZE ZYGO INTERFEROGRAMS
 - PREDICT DIHEDRAL ANGLES
 - TEST CUBES IN TWYMAN-GREEN INTERFEROMETER
 - ANALYZE ITEK INTERFEROGRAMS
 - PREDICT DIHEDRAL ANGLES
 - PREDICT FAR FIELD PATTERN
- TOLERANCE ANALYSIS (.9 - 2.1 ARC-SEC)
- MODEL COMPARISON (SAO)
- EVALUATE REWORKED CUBES
 - ANALYZE ZYGO INTERFEROGRAMS
 - PREDICT DIHEDRAL ANGLES
 - PREDICT FAR FIELD PATTERN

SUMMARY - DIHEDRAL ANGLE

		<u>AVERAGE DIHEDRAL ANGLE (ARC-SEC)</u>
***	ITEK INTERFEROGRAMS	1.77
***	ZYGO INTERFEROGRAMS	1.86
*	ITEK FFDP	1.98
**	BENDIX FFDP	2.14

*Based on far field pattern predicted from interferograms.

**Based on far field pattern photograph measurement.

***Analyzed by Itek.

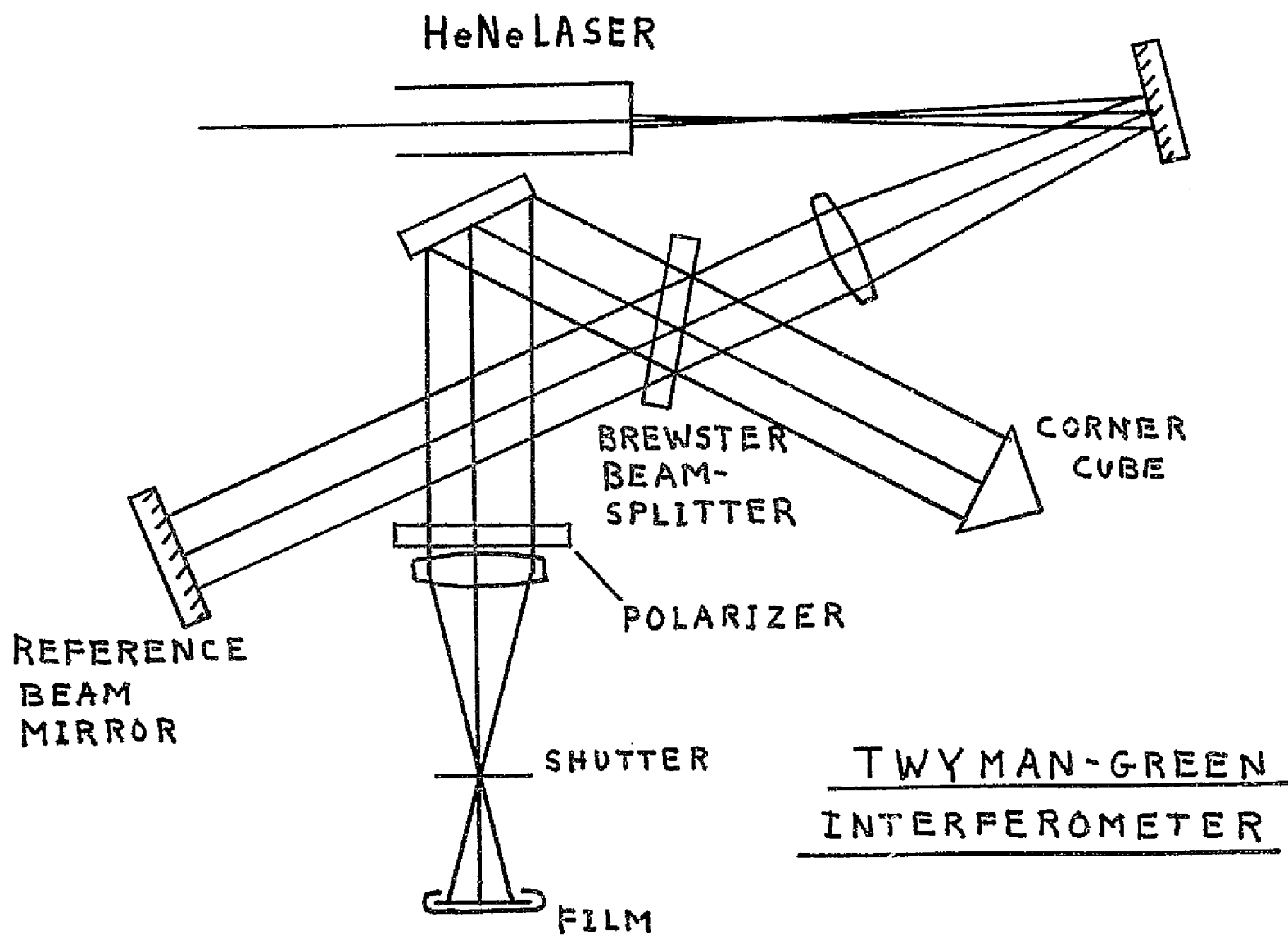
63

SUMMARY - FAR FIELD DIFFRACTION PATTERN

	<u>AVERAGE PERCENT ENERGY IN 13.2 - 16.9 ARC-SEC ANNULUS</u>	<u>AVERAGE ANNULUS DIAMETER (ARC-SEC)</u>
ITEK INTERFEROGRAM	14.3	18.0
BENDIX MEASUREMENT	9.7	20.3

SUMMARY - TOLERANCE STUDY

- PERCENT ENERGY IN 13.2 - 16.9 ARC-SEC ANNULUS VARIES FROM 13.0 TO 18.5 FOR DIHEDRAL ANGLES OF .9-2.1 ARC-SEC
- PEAK PERCENT ENERGY OCCURS AT ABOUT 1.35 ARC-SEC DIHEDRAL ANGLE.
- ANNULUS DIAMETER VARIES FROM 12.4 TO 22.0 ARC-SEC FOR DIHEDRAL ANGLES OF .9 - 2.1 ARC-SEC.
- OFF-NOMINAL CUBE (1.0, +.5, -.5 ARC-SEC ERRORS) INCREASES ANNULUS DIAMETER BY UP TO 1.0 ARC-SEC AND CHANGES PERCENT ENERGY BY UP TO 0.7.

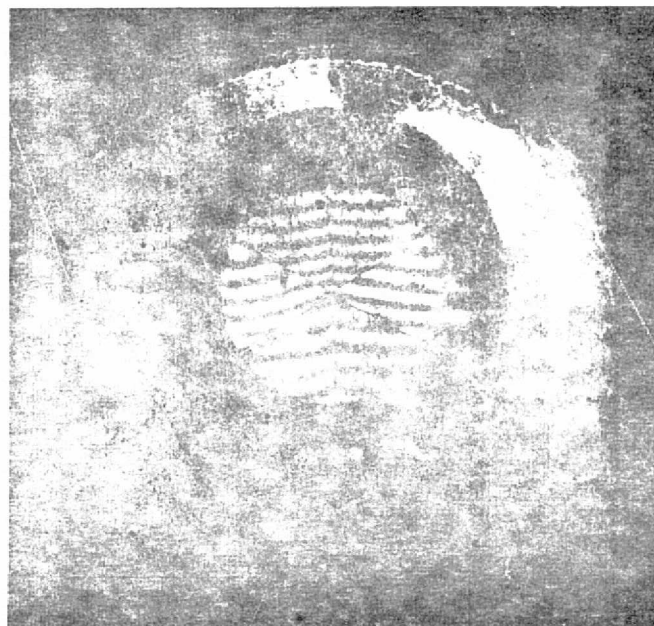
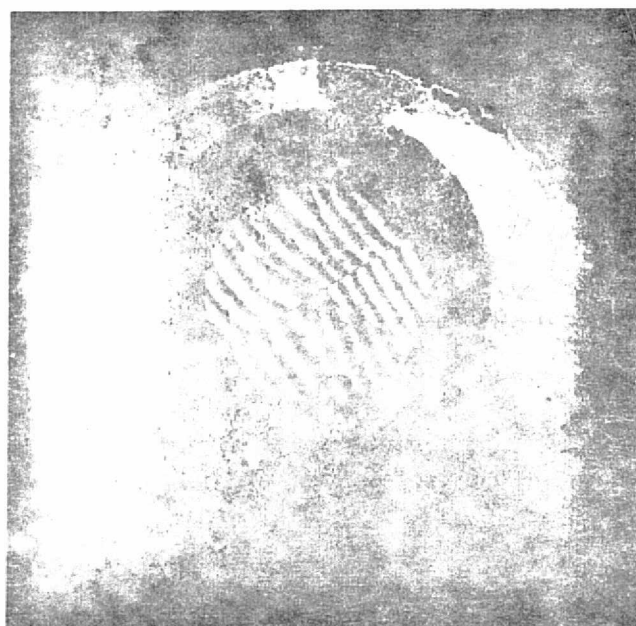


TEST PROCEDURE

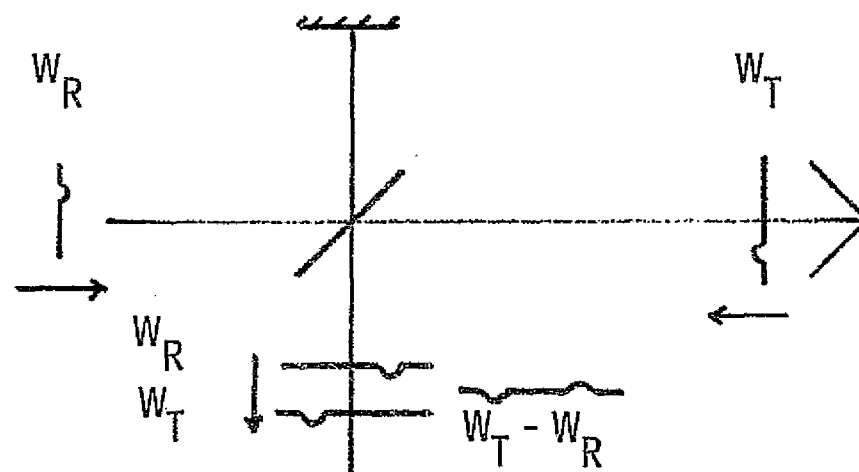
1. CLEAN AND MOUNT CORNER CUBE.
2. TILT CORNER CUBE ~ 1 DEGREE TO AVOID GLINT.
3. ORIENT POLARIZER.
4. WAIT 20 MINUTES AFTER LAST HANDLING.
5. ORIENT FRINGES PERPENDICULAR TO EACH REAL EDGE.
6. PHOTOGRAPH INTERFEROGRAM.
7. DATA REDUCTION.

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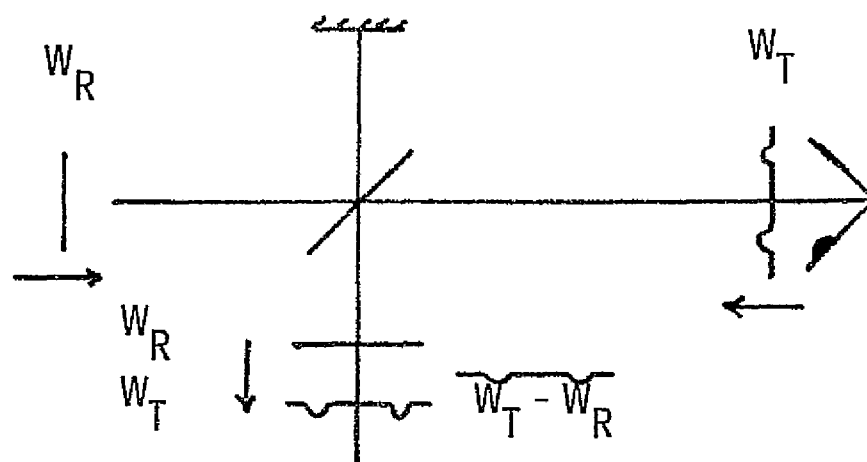
INTERFEROGRAMS OF RETROREFLECTOR #3



INTERFEROMETRY OF RETROREFLECTORS



INTERFEROMETER ERROR
RADIALLY ANTI-SYMMETRIC



RETROREFLECTOR ERROR
RADIALLY SYMMETRIC

ANALYSIS OF RETROREFLECTOR INTERFEROGRAMS

MEASURED WAVEFRONT: $W(x, y)$

RETROREFLECTOR ERROR: $1/2 [W(x, y) + W(-x, -y)]$

INTERFEROMETER ERROR: $1/2 [W(x, y) - W(-x, -y)]^2$

ANALYSIS OF RETROREFLECTOR INTERFEROGRAMS (CONTINUED)

FAR FIELD PATTERN

MEASURED PHASE IS FOR COMPONENT PARALLEL TO INPUT.

USE THEORETICAL INTENSITY VARIATIONS.

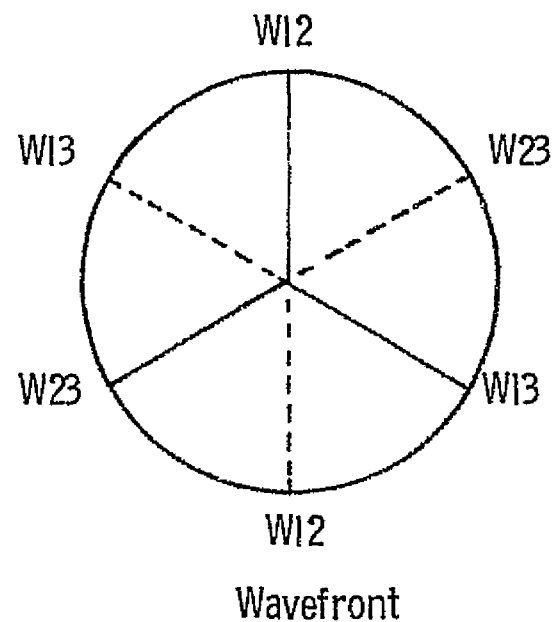
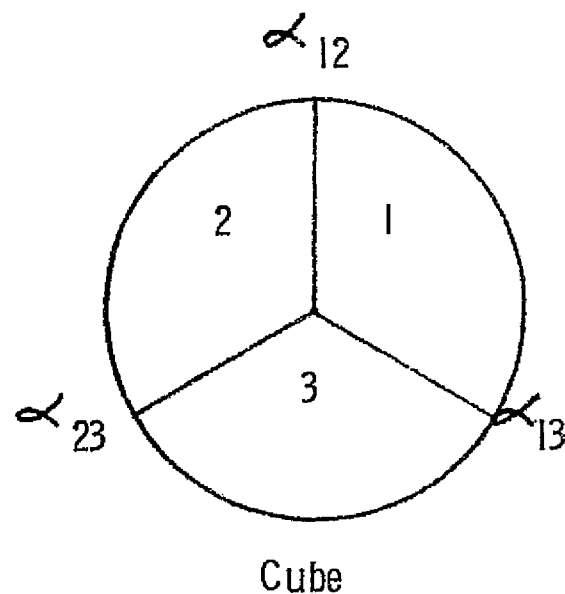
ADD THEORETICAL PHASE SHIFTS FOR PERPENDICULAR COMPONENT.

DIHEDRAL ANGLE

FIT PLANE THROUGH EACH SEXTANT TO GET AVERAGE SLOPE.

CALCULATE DIHEDRAL ANGLES.

CALCULATION OF DIHEDRAL ANGLES FROM INTERFEROGRAM



$$\alpha_{12} = \sqrt{\frac{1}{2} n D}$$

$$\alpha_{13} = \sqrt{\frac{1}{2} n D}$$

$$\alpha_{23} = \sqrt{\frac{1}{2} n D}$$

$$[W_{13} + W_{23} - W_{12}]$$

$$[W_{23} + W_{12} - W_{13}]$$

$$[W_{12} + W_{13} - W_{23}]$$

n = index
D = diameter

INTERFEROMETRIC MEASUREMENT OF DIHEDRAL ANGLES (arc-sec)

Cube	<u>Interferogram</u>												Ave
	<u>1</u>			<u>2</u>			<u>3</u>			<u>Average</u>			
1	1.38	1.71	1.87	1.53	1.68	2.01	1.63	1.90	1.98	1.51	1.76	1.95	1.74
2	1.62	2.19	2.03	1.64	1.91	1.82	1.77	2.00	2.08	1.68	2.03	1.98	1.90
3	1.32	1.30	1.61	1.30	1.38	1.59	1.38	1.53	1.53	1.33	1.40	1.58	1.44
4	1.83	1.67	1.87	1.86	1.87	1.76	1.86	1.72	1.92	1.85	1.75	1.85	1.82
5	2.24	2.38	2.01	2.23	2.28	1.94	2.19	2.10	1.88	2.22	2.25	1.94	2.14
6	1.76	1.64	1.51	1.50	1.68	1.59	1.56	1.44	1.65	1.61	1.59	1.58	1.59
Average													1.77

(1 σ = .07 Arc-Sec)

COMPARISON OF DIHEDRAL ANGLES ON CUBES 1, 2, AND 4

<u>Cube</u>	<u>*Itek Interferograms</u>			<u>*Zygo Interferograms</u>			<u>Moore Mechanical Measurements</u>		
1	1.51	1.76	1.95	2.44	1.84	2.04	2.14	2.00	1.72
2	1.68	2.03	1.98	1.98	1.76	0.98	1.68	1.84	1.76
4	1.85	1.75	1.85	2.02	1.31	1.65	1.82	1.80	1.80
Average	1.82			1.78			1.84		

*Analyzed by Itek.

COMPARISON OF AVERAGE DIHEDRAL ANGLE (arc-sec)

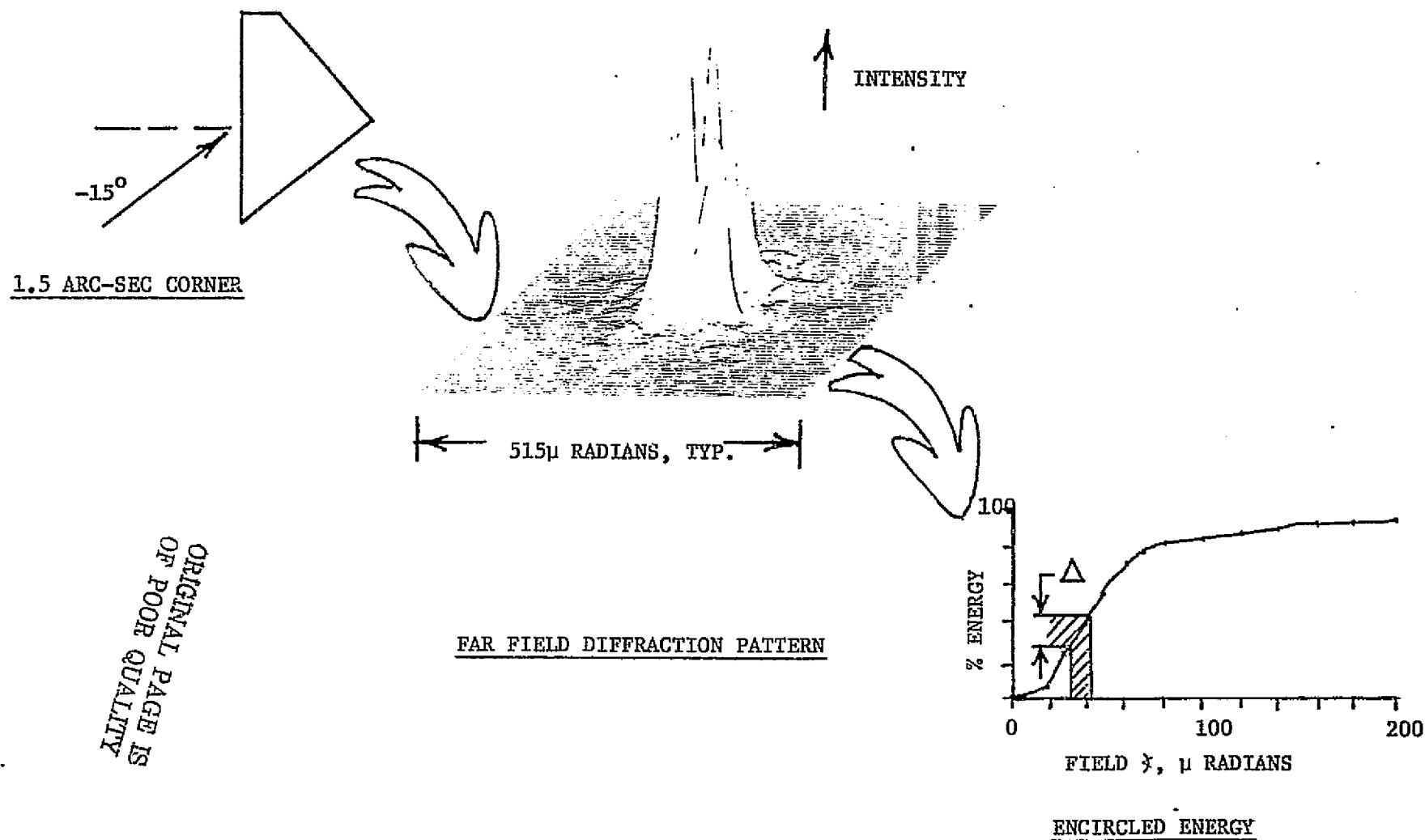
<u>Cube</u>	<u>*** Itek Interferogram</u>	<u>*** Zygo Interferogram</u>	<u>*Itek FFDP</u>	<u>**Bendix FFDP</u>
1	1.74	2.11	1.96	2.32
2	1.90	1.57	2.13	2.08
3	1.44	1.78	1.74	1.85
4	1.82	1.66	1.96	2.17
5	2.14	2.31	2.30	2.48
6	1.59	1.71	1.78	1.94
Average	1.77	1.86	1.98	2.14

*Based on far field pattern predicted from interferograms.

**Based on far field pattern photograph measurement.

***Analyzed by Itek.

FAR-FIELD CHARACTERISTICS



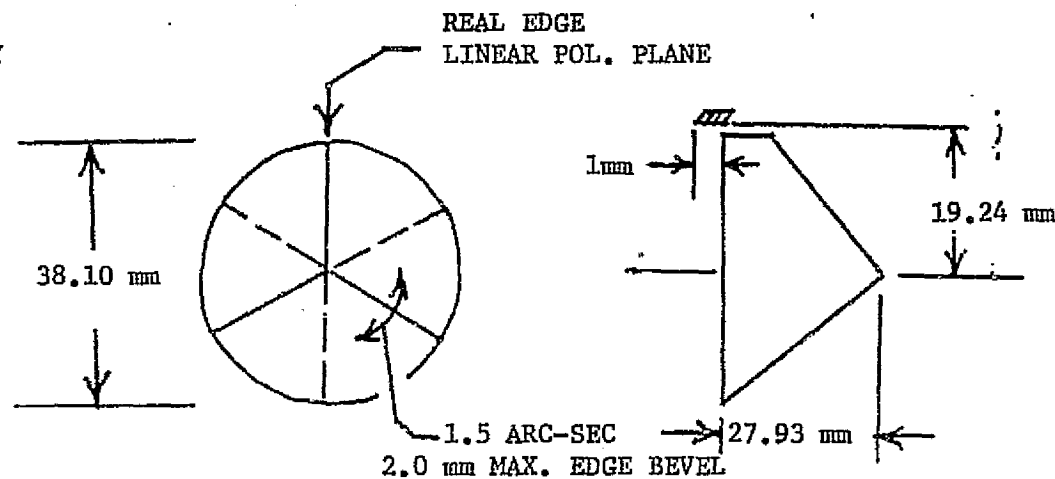
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ASSUMPTIONS/INPUTS

MATERIAL

- T-19 SUPRASIL 1 (SPECIAL)
- AMERSIL DATA - $N(\lambda)$, $\partial n/\partial T (\lambda, T, P) \rightarrow 7$ to $8.5 \times 10^{-6}/^{\circ}\text{C}$
- HOMOSIL, CONSERVATIVE

GEOMETRY

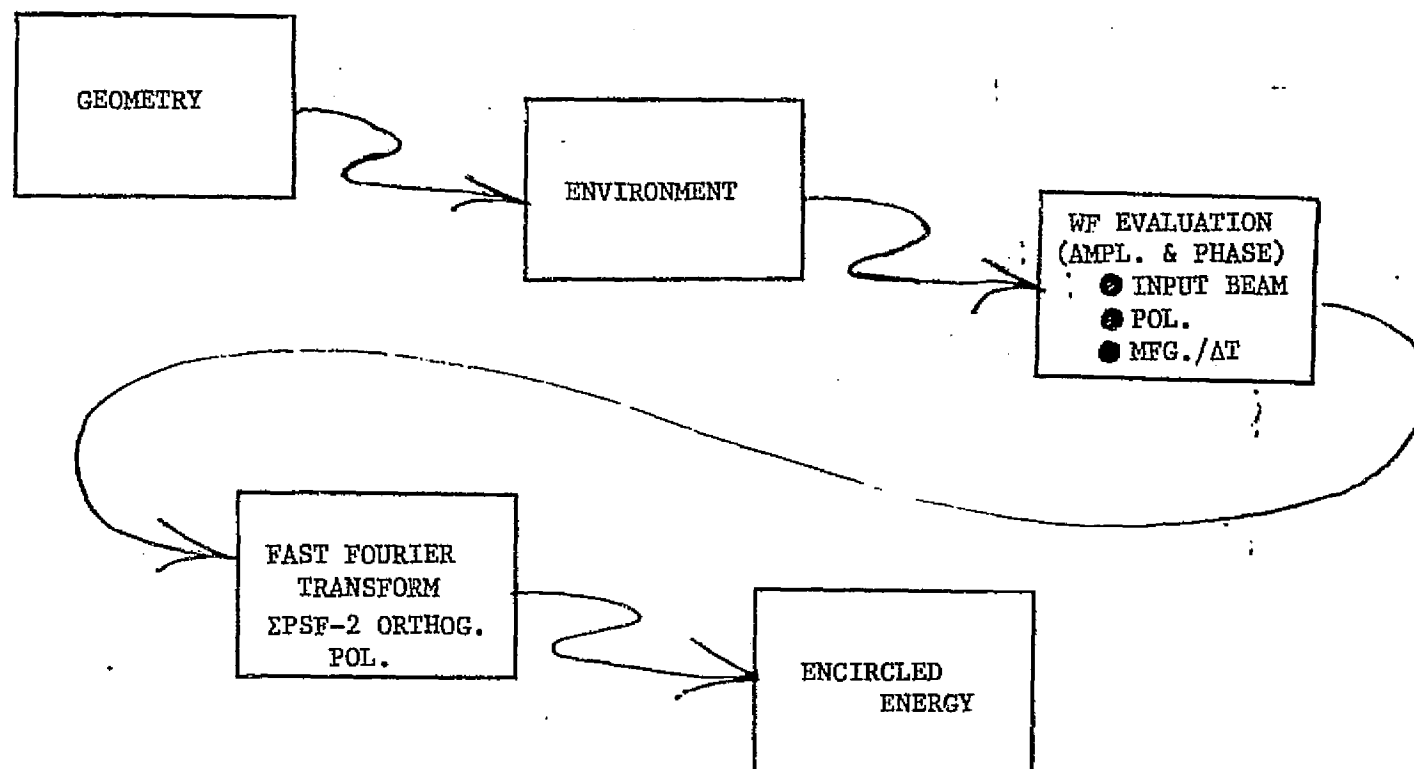


LASER

- 6328A, FLAT WF, CENTERED
- 20% GAUSSIAN VARIATION OVER 50 mm DIAMETER

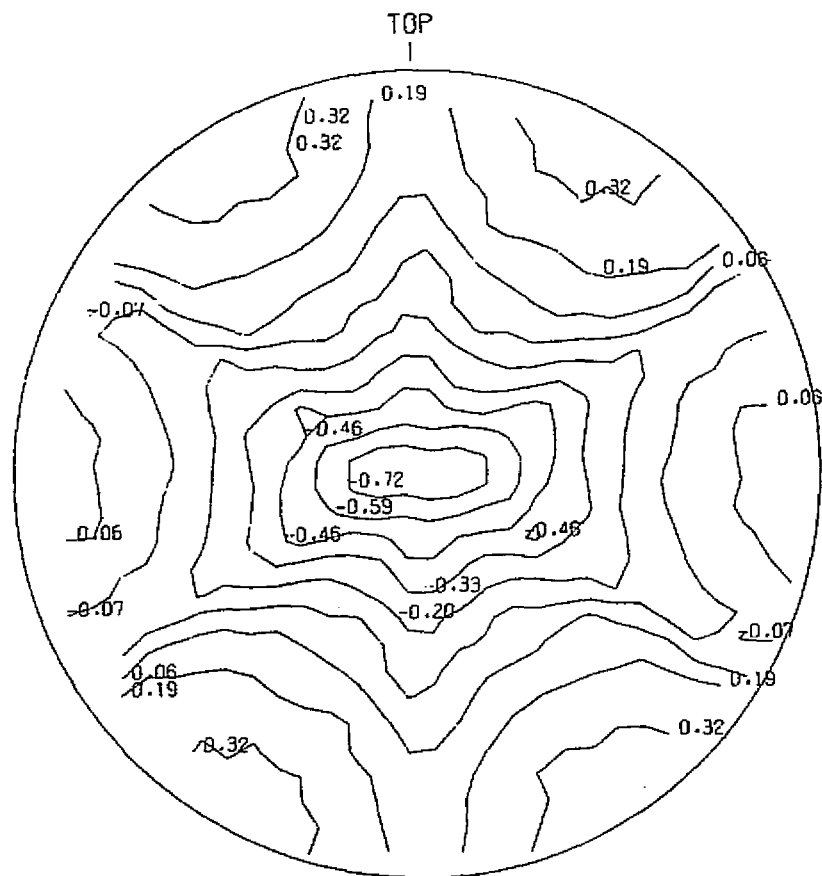
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TECHNIQUES/MODEL

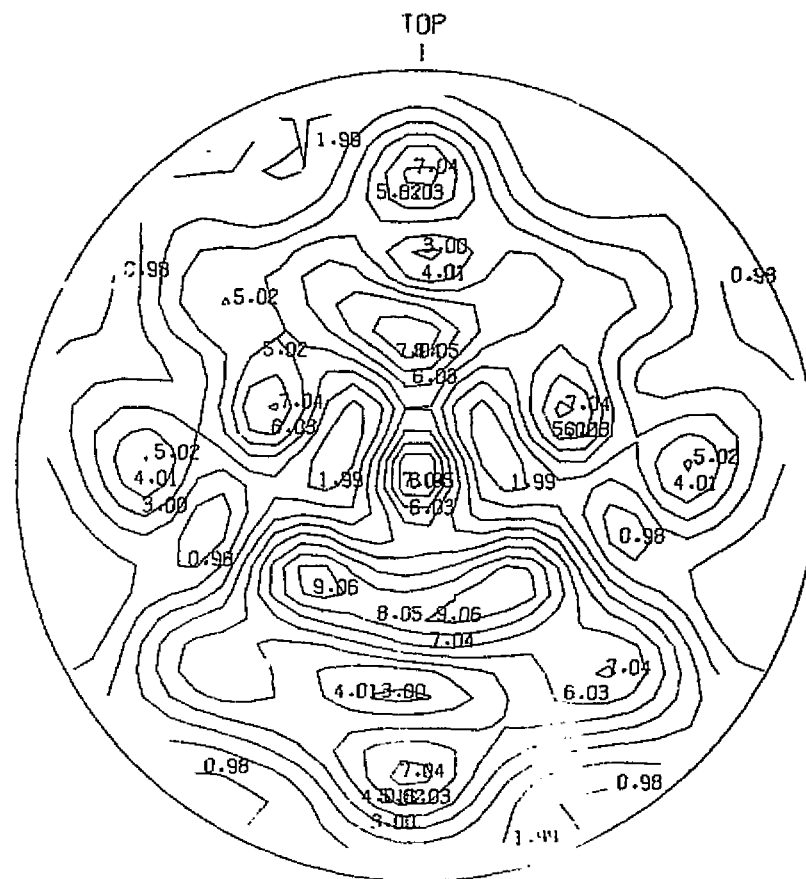


ACCURACY ~ 1% IN ENCIRCLED ENERGY

Wavefront Plot
Q Polarization

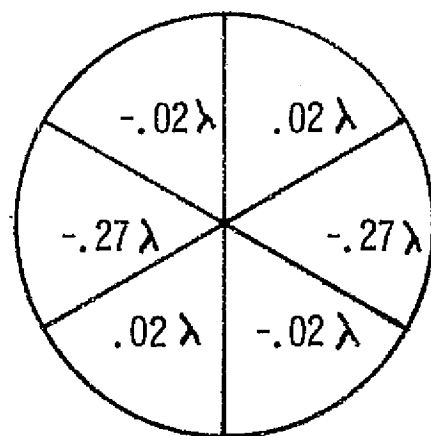


Intensity Distribution
Central 129 Microradians



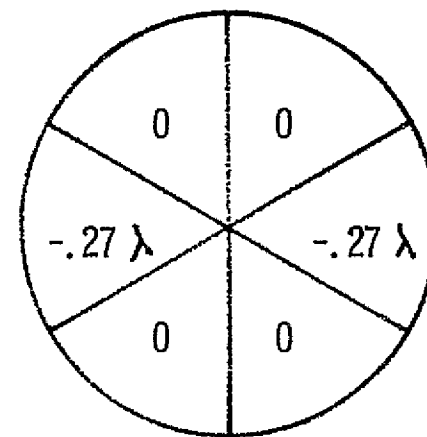
1022

PHASE SHIFT DUE TO POLARIZATION



INTERFEROMETRIC
MEASUREMENT

$$(|\sigma| = .02\lambda)$$



THEORETICAL

FAR FIELD CHARACTERISTICS OF LAGEOS
RETROREFLECTOR - ON-AXIS

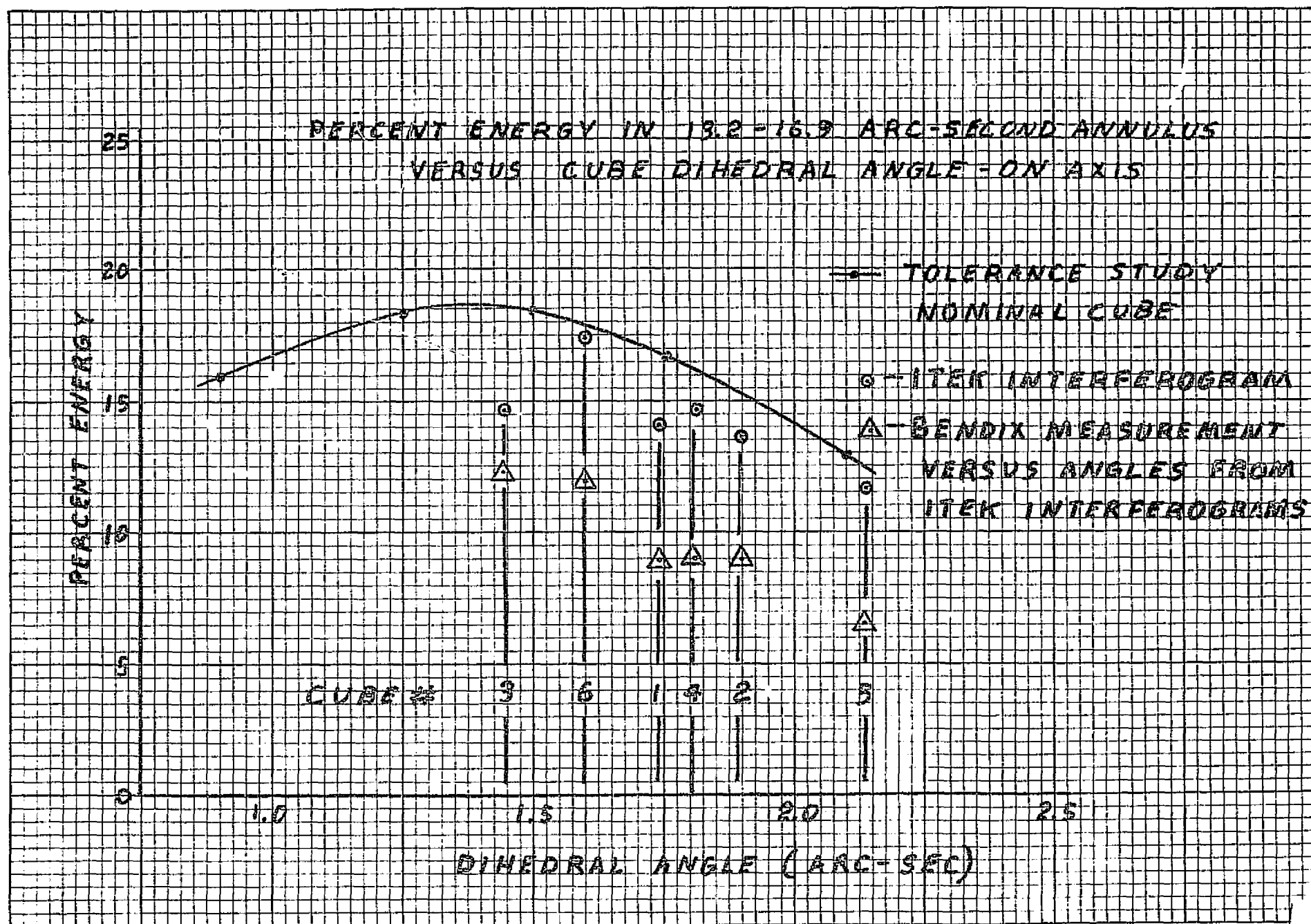
<u>Cube #</u>	Percent Energy 13.2 - 16.9 Arc-Sec		Annulus Diameter (Arc-Sec)	
	<u>Itek Interferogram</u>	<u>Bendix Measurement</u>	<u>Itek Interferogram</u>	<u>Bendix Measurement</u>
1	14.0	8.9	18.6	22.0
2	13.6	8.9	20.2	19.8
3	14.7	12.4	14.4	17.6
4	14.6	9.0	18.6	20.6
5	11.7	6.7	21.9	23.5
6	17.4	12.0	14.4	18.4
Average	14.3	9.7	18.0	20.3

TOLERANCE STUDY
Encircled Energy & Apparent
Annulus Diameter
On-Axis

<u>Case</u>	<u>Percent Energy 13.2 - 16.9 Arc-Sec</u>	<u>Apparent Annulus Diameter (Arc-Sec)</u>
0.9 Arc-Sec Nominal Cube	16.0	12.4
* 0.9 Arc-Sec Off Nominal Cube	16.7	13.4
1.25 Arc-Sec Nominal Cube	18.3	14.4
1.5 Arc-Sec Nominal Cube	18.5	16.5
* 1.5 Arc-Sec Off Nominal Cube	18.2	17.3
1.75 Arc-Sec Nominal Cube	16.8	18.6
2.1 Arc-Sec Nominal Cube	13.0	22.0
* 2.1 Arc-Sec Off Nominal Cube	12.3	22.4

*.0, +.5, -.5 Arc-Sec Errors

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ANNULUS CENTROID DIAMETER VERSUS CUBE DIHEDRAL ANGLE ON AXIS

ANNULUS DIAMETER (ARC-SEC)

DIHEDRAL ANGLE (ARC-SEC)

TOLERANCE STUDY OFF NOM.
TOLERANCE STUDY NOM.
GEOMETRICAL PREDICTION
ITEK INTERFEROGRAMS
BENDIX MEASUREMENT
VS ITEK DIHEDRAL ANGLES
TOLERANCE STUDY
NO POLARIZATION

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SUMMARY

- AVERAGE DIHEDRAL ANGLE IS 1.8 ARC-SEC.
- AVERAGE FAR FIELD ANNULUS DIAMETER IS 18.0 ARC-SEC.
- PEAK ENERGY IN 13.2 - 16.9 ARC-SEC ANNULUS OCCURS FOR A 1.35 ARC-SEC CUBE.
- .0, +.5, -.5 ARC-SEC ERRORS INCREASE ANNULUS DIAMETER SLIGHTLY.
- MEASURED FFDP SHOWS CONSISTENTLY HIGH ANNULUS DIAMETER AND LOW PERCENT ENERGY IN 13.2 - 16.9 ARC-SEC ANNULUS.

PRELIMINARY CONCLUSIONS/RECOMMENDATIONS

- FAR FIELD ANNULUS IS LARGER THAN GEOMETRICAL PREDICTION DUE TO DIFFRACTION/POLARIZATION.
- NOMINAL DIHEDRAL ANGLES SHOULD BE REDUCED TO 1.25 ARC-SEC.
- ANALYZE AND TEST REWORKED CUBES AS PLANNED.
- CONSIDER ANALYSIS FOR OTHER INCIDENT ANGLES AND WAVELENGTHS.

LAGEOS
DIHEDRAL ANGLE IMPROVEMENT PROGRAM
PREPARED UNDER
CONTRACT TO
BENDIX AEROSPACE SYSTEMS DIVISION
18 DECEMBER 1974

Itek

PURPOSE/OBJECTIVES

RESOLVE CONTRADICTIONS IN TEST RESULTS

- PREDICT DIHEDRAL ANGLES FROM INTERFEROGRAMS
COMPARE WITH INDEPENDENT MEASUREMENTS
- PREDICT FAR FIELD PATTERN FROM INTERFEROGRAMS
COMPARE WITH MEASURED DATA
- MAKE DECISION ON REVISED DIHEDRAL ANGLE
- ANALYZE REWORKED CUBES

TASKS

- EVALUATE EXISTING CUBES
 - ANALYZE ZYGO INTERFEROGRAMS
 - PREDICT DIHEDRAL ANGLES
 - TEST CUBES IN TWYMAN-GREEN INTERFEROMETER
 - ANALYZE ITEK INTERFEROGRAMS
 - PREDICT DIHEDRAL ANGLES
 - PREDICT FAR FIELD PATTERN
- TOLERANCE ANALYSIS (.9 - 2.1 ARC-SEC)
- MODEL COMPARISON (SAO)
- EVALUATE REWORKED CUBES
 - ANALYZE ZYGO INTERFEROGRAMS
 - PREDICT DIHEDRAL ANGLES
 - PREDICT FAR FIELD PATTERN

SUMMARY - DIHEDRAL ANGLE

		<u>AVERAGE DIHEDRAL ANGLE (ARC-SEC)</u>
***	ITEK INTERFEROGRAMS	1.77
***	ZYGO INTERFEROGRAMS	1.86
*	ITEK FFDP	1.98
**	BENDIX FFDP	2.14

*Based on far field pattern predicted from interferograms.

**Based on far field pattern photograph measurement.

***Analyzed by Itek.

SUMMARY - FAR FIELD DIFFRACTION PATTERN

	<u>AVERAGE PERCENT ENERGY IN 13.2 - 16.9 ARC-SEC ANNULUS</u>	<u>AVERAGE CENTROID DIAMETER (ARC-SEC)</u>
ITEK INTERFEROGRAM	14.3	18.7
BENDIX MEASUREMENT	9.7	20.3

SUMMARY - TOLERANCE STUDY

- PERCENT ENERGY IN 13.2 - 16.9 ARC-SEC ANNULUS VARIES FROM 13.0 TO 18.5 FOR DIHEDRAL ANGLES OF .9-2.1 ARC-SEC
- PEAK PERCENT ENERGY OCCURS AT ABOUT 1.35 ARC-SEC DIHEDRAL ANGLE.
- CENTROID DIAMETER VARIES FROM 12.4 TO 22.0 ARC-SEC FOR DIHEDRAL ANGLES OF .9 - 2.1 ARC-SEC.
- OFF-NOMINAL CUBE (.0, +.5, -.5 ARC-SEC ERRORS) INCREASES CENTROID DIAMETER BY UP TO 1.0 ARC-SEC AND CHANGES PERCENT ENERGY BY UP TO 0.7.

COMPARISON OF DIHEDRAL ANGLES ON CUBES 1, 2, AND 4

<u>Cube</u>	<u>*Itek Interferograms</u>			<u>*Zygo Interferograms</u>			<u>Moore Mechanical Measurements</u>		
1	1.51	1.76	1.95	2.44	1.84	2.04	2.14	2.00	1.72
2	1.68	2.03	1.98	1.98	1.76	0.98	1.68	1.84	1.76
4	1.85	1.75	1.85	2.02	1.31	1.65	1.82	1.80	1.80
<hr/>									
Average	1.82			1.78			1.84		

*Analyzed by Itek.

COMPARISON OF AVERAGE DIHEDRAL ANGLE (arc-sec)

<u>Cube</u>	<u>*** Itek Interferogram</u>	<u>*** Zygo Interferogram</u>	<u>*Itek FFDP</u>	<u>**Bendix FFDP</u>
1	1.74	2.11	1.96	2.32
2	1.90	1.57	2.13	2.08
3	1.44	1.78	1.74	1.85
4	1.82	1.66	1.96	2.17
5	2.14	2.31	2.30	2.48
6	1.59	1.71	1.78	1.94
Average	1.77	1.86	1.98	2.14

*Based on far field pattern predicted from interferograms.

**Based on far field pattern photograph measurement.

***Analyzed by Itek.

FAR FIELD CHARACTERISTICS OF LAGEOS RETROREFLECTOR - ON-AXIS

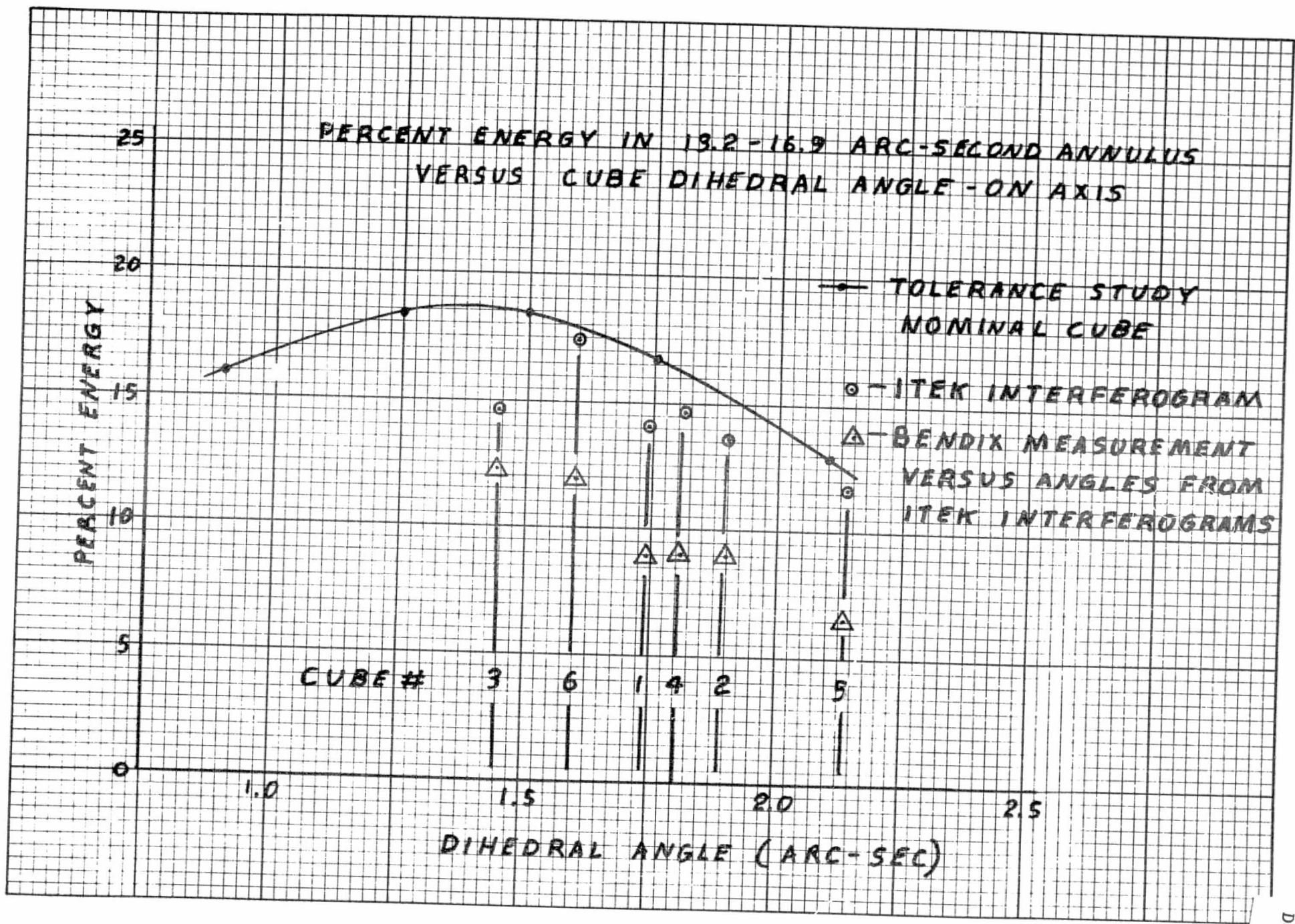
<u>Cube #</u>	Percent Energy 13.2 - 16.9 Arc-Sec		Centroid Diameter (Arc-Sec)	
	<u>Itek Interferogram</u>	<u>Bendix Measurement</u>	<u>Itek Interferogram</u>	<u>Bendix Measurement</u>
1	14.0	8.9	18.6	22.0
2	13.6	8.9	20.2	19.8
3	14.7	12.4	16.4	17.6
4	14.6	9.0	18.6	20.6
5	11.7	6.7	21.9	23.5
6	17.4	12.0	16.6	18.4
Average	14.3	9.7	18.7	20.3

TOLERANCE STUDY
Encircled Energy & Apparent
Centroid Diameter
On-Axis

<u>Case</u>	<u>Percent Energy 13.2 - 16.9 Arc-Sec</u>	<u>Apparent Centroid Diameter (Arc-Sec)</u>
0.9 Arc-Sec Nominal Cube	16.0	12.4
* 0.9 Arc-Sec Off Nominal Cube	16.7	13.4
1.25 Arc-Sec Nominal Cube	18.3	14.4
1.5 Arc-Sec Nominal Cube	18.5	16.5
* 1.5 Arc-Sec Off Nominal Cube	18.2	17.3
1.75 Arc-Sec Nominal Cube	16.8	18.6
2.1 Arc-Sec Nominal Cube	13.0	22.0
* 2.1 Arc-Sec Off Nominal Cube	12.3	22.4

*.0, +.5, -.5 Arc-Sec Errors

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ANNULUS CENTROID DIAMETER VERSUS CUBE DIHEDRAL ANGLE ON AXIS

ANNULUS DIAMETER (ARC-SEC)

20

15

10

1.0

1.5

2.0

2.5

DIHEDRAL ANGLE (ARC-SEC)

TOLERANCE STUDY OFF NOM.

TOLERANCE STUDY NOM.

GEOMETRICAL PREDICTION

ITEK INTERFEROGRAMS

BENDIX MEASUREMENT
VS ITEK DIHEDRAL ANGLES

TOLERANCE STUDY
NO POLARIZATION

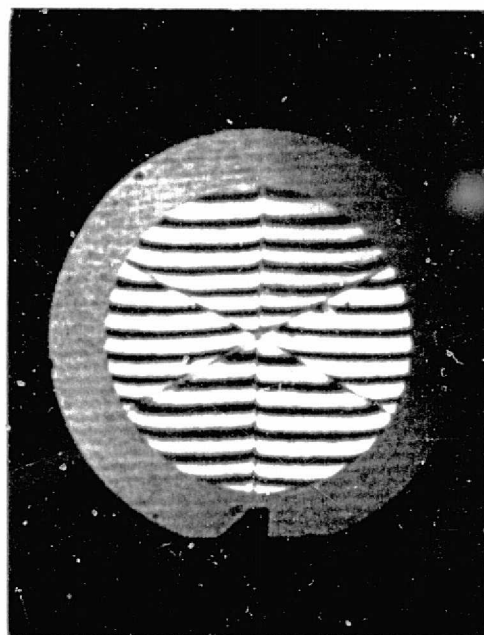
SUMMARY

- AVERAGE DIHEDRAL ANGLE IS 1.8 ARC-SEC.
- AVERAGE FAR FIELD CENTROID DIAMETER IS 18.0 ARC-SEC.
- PEAK ENERGY IN 13.2 - 16.9 ARC-SEC CENTROID OCCURS FOR A 1.35 ARC-SEC CUBE.
- .0, +.5, -.5 ARC-SEC ERRORS INCREASE ANNULUS DIAMETER SLIGHTLY.
- MEASURED FFDP SHOWS CONSISTENTLY HIGH CENTROID DIAMETER AND LOW PERCENT ENERGY IN 13.2 - 16.9 ARC-SEC ANNULUS.

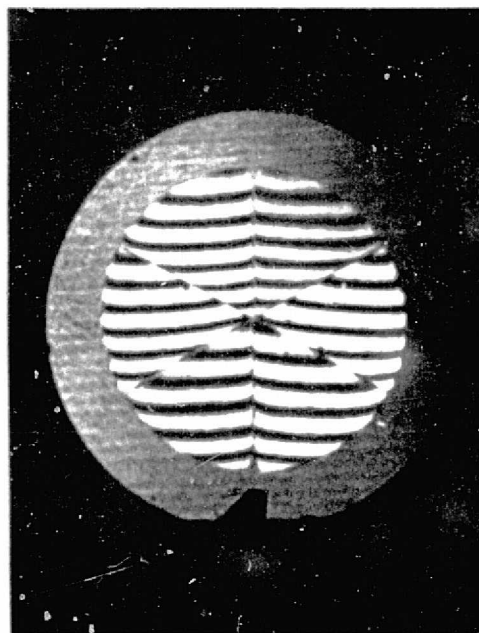
PRELIMINARY CONCLUSIONS/RECOMMENDATIONS

- INTERFEROMETRIC MEASUREMENT OF DIHEDRAL ANGLES AGREES WITH MECHANICAL MEASUREMENTS ON THE AVERAGE
- PREDICTED FFDP DIFFRACTION PATTERNS AGREE WITH MEASURED PATTERNS CLOSER THAN PREVIOUS PREDICTIONS
- FAR FIELD ANNULUS IS LARGER THAN GEOMETRICAL PREDICTION DUE TO DIFFRACTION/POLARIZATION
- NOMINAL DIHEDRAL ANGLES SHOULD BE REDUCED TO APPROXIMATELY 1.25 ARC-SEC.
- ANALYZE AND TEST REWORKED CUBES AS PLANNED
- CONSIDER ANALYSIS FOR OTHER INCIDENT ANGLES AND WAVE LENGTHS

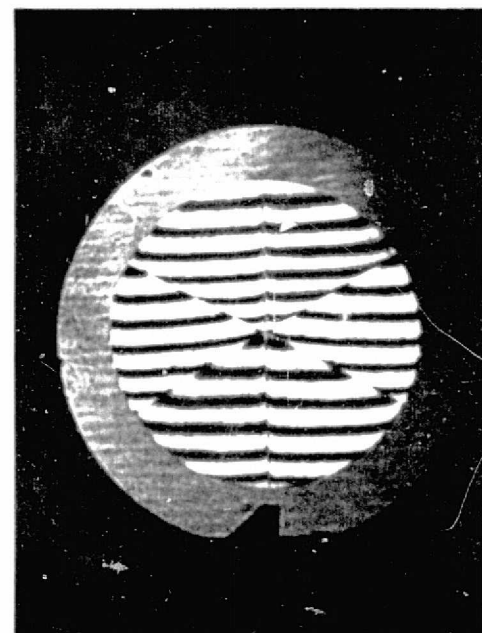
INTERFEROGRAMS OF REWORKED CUBES



#1 RW



#2 RW



#3 RW

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INTERFEROMETRIC MEASUREMENT OF DIHEDRAL ANGLES
ON REWORKED CUBES (ARC-SEC)

REWORKED CUBE	INTERFEROGRAM									AVERAGE	AVE.
	1			2			3				
1	.73	.30	.45	.79	.38	.33	.83	.28	.30	.78 .32 .36	.49
2	.67	.89	.77	.58	.91	.73	.91	.79	.59	.72 .86 .70	.76
3	.28	.17	.40	.24	.30	.16	.25	.26	.30	.26 .24 .29	.26

* BASED ON INTERFEROGRAM PRODUCED BY ZYGO AND ANALYZED BY ITEK

COMPARISON OF DIHEDRAL ANGLES ON REWORKED CUBES (ARC-SEC)

REWORKED CUBE	ITEK			AVE.	ZYGO MECHANICAL MEASUREMENT			AVE.	DIFFERENCE
	INTERFEROGRAM *								
1	0.78	0.32	0.36	0.49	0.97	1.10	0.86	0.98	0.49
2	0.72	0.86	0.70	0.76	1.37	1.26	1.24	1.29	0.53
3	0.26	0.24	0.29	0.26	0.72	0.84	0.82	0.79	0.55

* BASED ON INTERFEROGRAM PRODUCED BY ZYGO AND ANALYZED BY ITEK

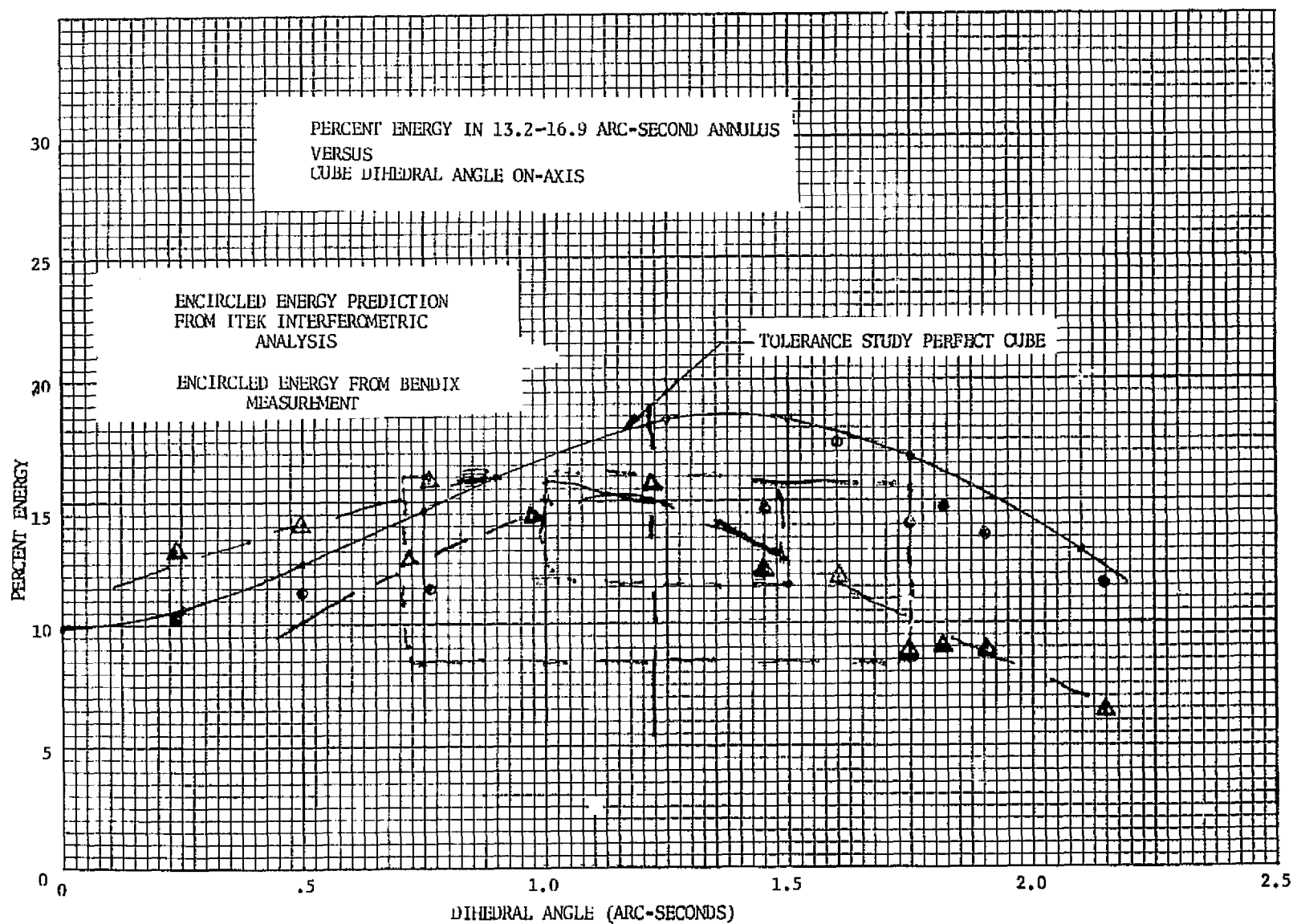
FAR FIELD CHARACTERISTICS OF REWORKED CUBES ON AXIS

REWORKED CUBE	PERCENT ENERGY 13.2 - 16.9 ARC SEC		CENTROID DIAMETER (ARC- SEC)	
	ITEK INTERFEROGRAM	BENDIX MEASUREMENT	ITEK INTERFEROGRAM	BENDIX MEASURED
1	11.35	14.0	9.4	13.2
2	11.5	16.0	10.5	14.7
3	10.4	13.0	7.9	12.5

* BASED ON INTERFEROGRAM PRODUCED BY ZYGO AND ANALYZED BY ITEK

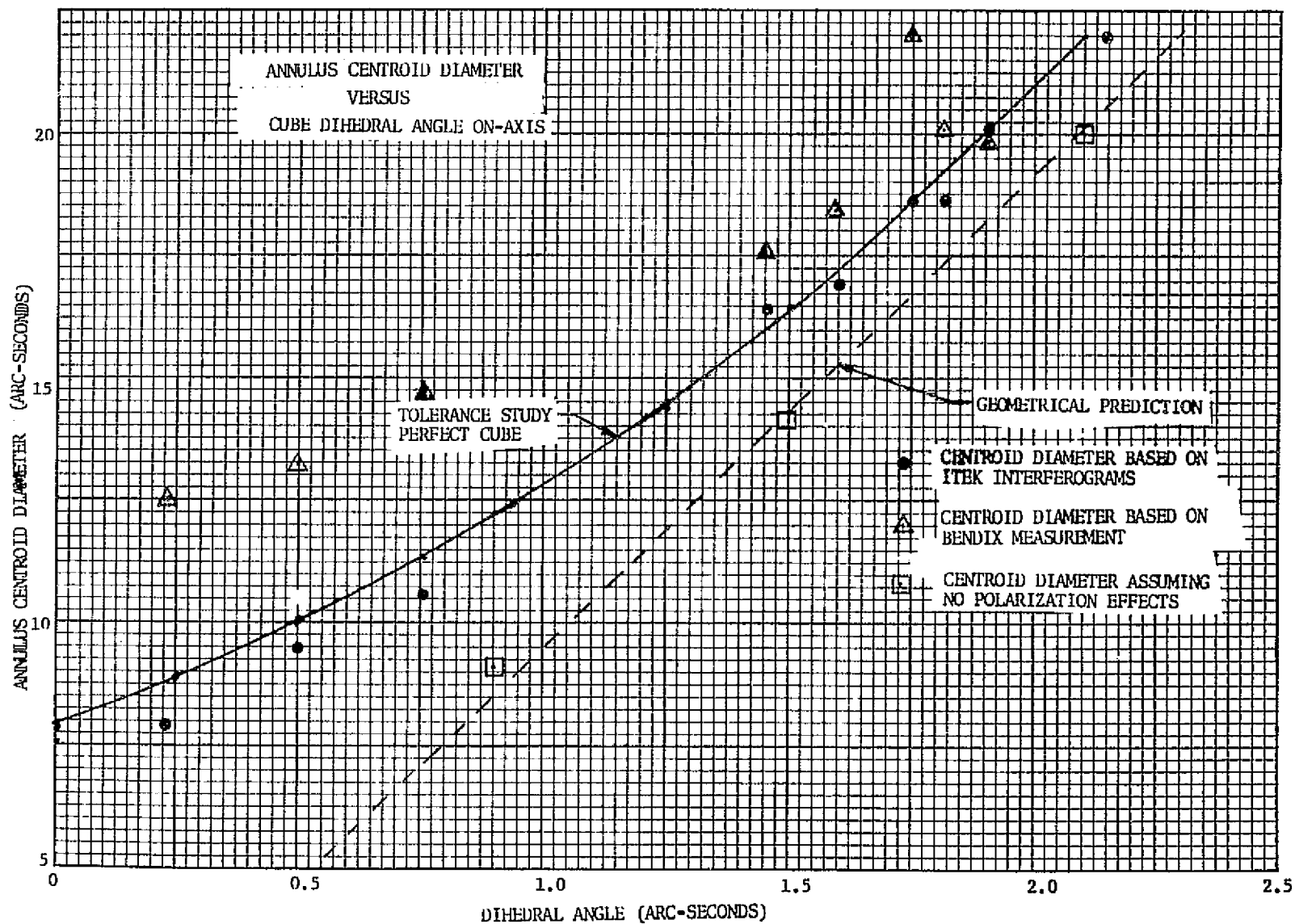
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MODEL COMPARISON (SAO)

- DISCREPANCIES IN FAR FIELD INTENSITY OF UP TO 10 PERCENT OF PEAK INTENSITY BETWEEN ITEK AND SAO MODEL
- MODIFICATIONS WERE MADE TO ITEK MODEL
- AGREEMENT WITH SAO MODEL OBTAINED
- EFFECT ON RESULTS LESS THAN 0.1% OF TOTAL ENERGY IN 13.2 - 16.9 ARC-SECOND ANNULUS

SUMMARY

- INTERFEROMETRICALLY PREDICTED DIHEDRAL ANGLES ON REWORKED CUBES SMALLER THAN THE DESIRED ANGLES BY ABOUT 0.5 ARC-SECOND
- MECHANICAL MEASUREMENTS OF DIHEDRAL ANGLES ON REWORKED CUBES ARE 0.5 ARC-SECOND LARGER THAN INTERFEROMETRIC PREDICTIONS
- MEASURED FFDP FOR REWORKED CUBES HAS HIGHER PERCENT ENERGY IN ANNULUS THAN INTERFEROMETRIC PREDICTIONS
- INTERFEROMETRICALLY PREDICTED CENTROID DIAMETER FOR REWORKED CUBES IS SMALLER THAN BENDIX MEASUREMENT
- EFFECT OF DISCREPANCIES WITH SAO RESULT IN DEVIATIONS LESS THAN 0.1% IN 13.2-16.9 ARC-SECONDS ANNULUS

CONCLUSIONS/RECOMMENDATIONS

- MEASURED FFDP HAS HIGHER PERCENT ENERGY IN ANNULUS AT LOWER DIHEDRAL ANGLES AND LOWER PERCENT ENERGY AT HIGHER DIHEDRAL ANGLES THAN INTERFEROMETRIC PREDICTIONS
 - DIFFERENCES COULD BE CAUSED BY A REDUCED ANNULUS DIAMETER
- MECHANICALLY MEASURED DIHEDRAL ANGLES FOR THE REWORKED CUBES HAVE A CONSTANT OFFSET FROM THE INTERFEROMETRICALLY PREDICTED DIHEDRAL ANGLES
- BASED ON INTERFEROMETRIC ANALYSIS DIHEDRAL ANGLES SHOULD BE 1.25 ± 0.5 ARC-SECONDS.
- PRODUCTION CUBES SHOULD BE CHECKED INTERFEROMETRICALLY TO VERIFY DIHEDRAL ANGLES.